Assessment of Intermodal Strategies for Airport Access

by

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16. Abstract

Air transportation plays a vital role in the Texas economy. Air passenger and air cargo traffic is projected to continue to increase considerably at many of the State's large airports. Ground access to airports is an important function which must be provided for at the regional level as well as in the immediate vicinity of the facility itself. Congestion problems affecting airport access are in some instances reaching unacceptable proportions, with negative impacts on air quality and other environmental considerations, and hence require concerted action to meet project needs.

To address the above challenges and current gaps, this study will take a comprehensive look at the land-side access issues associated with the major airports in the State. It will seek to improve on existing planning procedures and processes to meet the unique needs of airport traffic demand, for both people and goods. To be effective, planning for airport ground access must be multimodal and intermodal, consider both operational, regulatory and capital-intensive infrastructure provision issues, consider multiple levels of scale/resolution, and recognize the unique dynamic aspects of air traffic demand, i.e. its temporal patterns.

This report presents an overview and synthesis of the literature reviewed under the first task. The study team concludes that the motivation and the need for the ground access study is high and that existing approaches and documents are insufficient to meet the needs for strategic ground access planning of major airports in Texas.

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Executive Summary

Air transportation plays a vital role in the Texas economy. Air passenger and air cargo traffic is projected to continue to increase considerably at many of the state's large airports. Ground access to airports is an important function that must be provided at the regional level as well as in the immediate vicinity of the facility itself. Congestion problems affecting airport access are, in some instance,s reaching unacceptable proportions, with negative impacts on air quality and other environmental considerations. Accordingly, these issues require concerted action to meet project needs.

To address these challenges and current gaps, this project adopts a comprehensive look at the landside access issues associated with the major airports in the state. It seeks to improve on existing planning procedures and processes to meet the unique needs of airport traffic demand for both people and goods. To be effective, planning for airport ground access must be multimodal and intermodal; consider both operational, regulatory, and capital-intensive infrastructure provision issues; consider multiple levels of scale/resolution; and recognize the unique, dynamic aspects of air traffic demand, i.e., its temporal patterns. It must also consider carefully the potential of emerging Intelligent Transportation System (ITS) technologies in the airport environment.

In an effort to customize a state-of-the-art methodological approach for Texas airports, understanding users' behavior and likely responses is critical. There is a need to understand the relationship between ground access mode choice and the local airport market conditions and attributes, in order to provide a foundation for planning new and enhancing existing services. To this end, mode choice models help predict how much curbside space must be allocated to public transportation buses, courtesy shuttles, and taxi stands. These models, in conjunction with stated preferences regarding departure time and arrival time at the airport, provide useful insight into route decisions and the total trip experience of travelers. The use of new methodologies to simulate traffic congestion at and around airports can also be insightful, especially to evaluate the effect of new technologies. In particular, using DYNASMART-IP, a dynamic traffic assignment simulation tool developed at The University of Texas at Austin, it is possible to simulate traffic congestion surrounding the Dallas/Fort Worth International Airport, and to

evaluate the effectiveness of alternative access modes and strategies along with improvements to the highway system.

The report concludes that the major airports in Texas present unique access challenges that require intervention beyond the generalities of the *Planning Guide*, or any other available reference. The scope of these issues makes them inseparable from those of general transportation accessibility issues in the entire region of the airport. The scale and magnitude of these problems are likely to increase with continuing growth in airport-related traffic and activities. Institutional factors, involving cooperation and communication among several governmental and quasi-governmental entities, play a substantial role in ensuring an effective planning process that provides for the needs of air passengers and freight travel in the overall mobility of the region.

Chapter 1.
Introduction

Airports and air transportation will continue to play a vital and growing role in Texas's economic health and development. Air access is recognized as a critical ingredient in maintaining the roles of the Dallas/Fort Worth metroplex as a magnet for financial services, retail, and technology-based industries; Austin, as one of the world's preeminent microelectronics and software development centers; and Houston, as the pinnacle of the global oil industry and a center of aerospace and telecommunications business. It is projected that air traffic (passenger and freight) will continue to increase considerably at the state's largest airports. While such an increase is important to the economy, it could have crippling effects on ground access to the airports. Congestion problems affecting airport access are in some instances reaching unacceptable proportions, with negative impacts on air quality and other environmental considerations, and hence requiring concerted action to meet projected needs.

To address the above challenges and current gaps, this project takes a comprehensive look at the landside access issues associated with major airports in Texas. It seeks to improve on existing planning procedures and processes to meet the unique needs of airport traffic demand in Texas. To be effective, planning for airport ground access must be multimodal and intermodal; consider operational, regulatory, and capital-intensive infrastructure provision issues; consider multiple levels of scale and resolution; and recognize the unique dynamic aspects of air traffic demand, i.e., its temporal patterns. Using as a starting point the Federal Aviation Administration's (FAA) *Intermodal Ground Access to Airports: A Planning Guide*, this project expands the set of solution options to consider airport access in its strategic regional context, and further addresses specific issues encountered at Texas airports. Critical to this expansion is an overview of selected papers and reports augmented by a domestic and international study of intermodal strategies and best practice case studies.

The overall objective of this project is to provide Texas decision makers and planners with a set of relevant solution strategies aimed at alleviating landside access congestion at airports. This objective will be accomplished through the analysis of air traveler behavior and those factors that influence their travelers' preferred arrival time at the airport—as understood from the results of three surveys. Achieving this desired objective will be furthered through the development of a methodology by which various strategies (including different modes and off-airport terminals) can be compared. DYNASMART-IP will provide the means by which these solution strategies may be evaluated.

In an effort to customize a state-of-the-art methodological approach for Texas airports, understanding users' behavior and likely responses is critical. There is a need to understand the relationship between ground access mode choice and the local airport market conditions and attributes, in order to provide a foundation for planning new and enhancing existing services. To this end, mode choice models could help predict how much curbside space must be allocated to public transportation buses, courtesy shuttles, and taxi stands. These models, in conjunction with stated preferences regarding departure time and arrival time at the airport, can provide useful insight into route decisions and the total trip experience of travelers. The use of new methodologies to simulate traffic congestion at and around airports can also be insightful, especially in evaluating the effect of new technologies. In particular, using DYNASMART-IP, a dynamic traffic assignment simulation tool developed at The University of Texas at Austin, it is possible to simulate traffic congestion surrounding the Dallas/Fort Worth International Airport (DFW Airport). More important, however, is the ability to use DYNASMART-IP to simulate traffic flows after the implementation of improvement scenarios, including transit and off-airport terminals.

This report is divided into eight chapters. Chapter 2 presents a review of the related literature, including a review of sundry reports and articles covering various topics such as airport access, public transportation to airports, off-airport terminals, and dynamic traffic assignment. Chapter 3 details current best practices as determined from a study of successful domestic and international airports. A methodology and framework developing the structure for the following analysis of airport access is presented in Chapter 4. Chapters 5 and 6 are devoted to understanding access mode choice behavior with Chapter 5 outlining the background and administration of surveys for three Texas airports, and Chapter 6 describing the immediately relevant findings. Chapter 7 provides an evaluation of access in an intermodal network setting based on the results of several DYNASMART-IP model runs. Finally, the report concludes in Chapter 8 by presenting a summary of findings and recommendations to TxDOT for further implementation and possible future steps in the area of airport access.

Chapter 2.
Background Review

Introduction

Airport access has been discussed as a growing transportation problem in the United States since the early 1970s (Ref 1). The main function of airport landside access is to provide service to airport passengers and visitors, upon which cargo transport and airport employee travel are superimposed. As such, the access system must provide circulation, distribution, and storage of vehicles. However, the available infrastructure is limited and new facilities, when feasible, require very long lead times for completion. Thus, planners are faced with the challenge of managing demand by operating existing facilities efficiently (Ref 2).

Past air travel forecasts have typically underestimated aviation demand and have been narrow in scope, causing airport and landside facilities to outgrow their capacity and become inadequate to serve demand (Ref 2). This extreme growth is also causing a negative impact on the environment. Landside traffic generates more airborne pollutants than airside activities. Together, airside and landside air pollution have caused many airports to be identified as environmental hot spots (Ref 3). A congested groundside facility not only affects the environment, users increasingly experience more aggravation than necessary in accessing airport facilities. The impact of poor access has maximum implications for short-haul trips, where the ratio of access time to overall trip time is high (Ref 4). As a result, travelers tend to perceive access as an integral part of the total air trip, with the quality of access influencing their demand for air travel. Furthermore, travelers also view ease of access as a characteristic of the airport that may affect their choice of departure (or arrival) airport when alternatives are available. Thus, airport access is an important attribute of the product that is delivered by airports and airlines, and knowledge about access behavior should inform air transportation planning and management. (Ref 5).

An extensive review of available publications related to airport access operations planning has been compiled in a separate document in conjunction with the present project (Ref 6). This review is not duplicated here, and only selected highlights are included, particularly those related to the provision of modal alternatives for airport access. This includes public transportation to airports (rubber-tired and rail), off-airport terminals, and emerging technologies for airport access. The present review augments the previous document in several areas, including a focus on travelers' airport access choice processes.

Airport Landside Access

Airports are among the largest generators of people and goods traffic in metropolitan areas. From the perspective of a city's overall transport network, a major airport's trip generation is usually second only to that of the city's central business district (Ref 7). Ground traffic to and from airports is dispersed throughout most of the day, 7 days a week, originating from or destined to, points throughout the metropolitan area. Because the movement of people and goods to and from airports is so diffused over time and space, this traffic is carried mainly in low-occupancy vehicles, thus imposing a significant traffic load on roadways, particularly near the airport. As traffic volumes begin to cause congestion, a consolidation of person traffic into fewer vehicles becomes particularly important (Ref 8).

Access problems vary depending on attributes such as airport location and operation characteristics. A survey regarding ground transportation management practices and regulations was published in 1986. This questionnaire was developed to determine the characteristics of airport access services, existing problems, and improvement strategies nationwide. The questionnaire was sent to representatives of every large and medium-sized airport and every small airport with more than 500,000 annual enplanements (Ref 2). Table 2.1 provides an overview of the performance of airports nationwide in relation to twelve access problems dealing with roadways, human factors, and parking.

As shown in Table 2.1, each of the landside access limitations is perceived as a problem by at least 45% of the sampled airports. The problem most commonly reported is terminal curbside congestion, reported by 96% of respondents. In another survey, the Airports Council International-North America (ACI-NA) prepared a study of airport parking needs in 1994, and the results of that study are presented in Table 2.2 (Ref 2).

Table 2.1 Occurrence of landside access problems at U.S. airports

Landside Access Problem	Airports (%) Reporting Some Degree of Problem
Terminal curbside congestion: departures	96
Terminal curbside congestion: arrivals	96
Unfamiliar drivers weaving or causing backups	77
Long-term lots filled to capacity	71
Fare collection backups	68
Airport access road congestion	67
Short-term lots filled to capacity	64
Pedestrians causing safety concerns	63
Cars continuously circling to find a closer spot	58
Highway access ramp congestion	47
Pedestrians causing traffic backups	45
Satellite lots filled to capacity	45

Source: Ref. 2.

Table 2.2 Congestion at U.S. airports as reported by the ACI-NA study

	Airports (%) Reporting Some Degree of Problem		
	Large Airports	Medium-Sized Airports	Small Airports
Off-airport access roadway congestion	79	63	41
On-airport roadway congestion	68	69	34
Airport curbside congestion	89	92	72

Source: Ref 2.

It can be concluded that landside access to airports is a major concern at airports of all sizes, and there is no direct correlation between the severity of the reported access problems and the airport's size. Results of the national survey of airports indicate that a wide variety of landside access limitations exist and these limitations are present at airports of all sizes (Ref 2).

Public Transportation Access to Airports

The American Public Transportation Association (APTA) defines public transportation as "transportation by bus, rail, or other conveyance, either publicly or privately owned which provides service to the general public or special service on a regular and continuing basis." At airports, these services include express and multi-stop buses, rail service, shared-ride, and door-to-door vans. The ceiling on public transportation use by airline passengers in most cities appears to be about 10% to 15%, even at airports with rail service (Ref 9). It is convenient to divide public ground transportation services into two categories: rubber-tired and rail. The following subsections are based on this division.

Rubber-Tired Ground Transportation

The typical public rubber-tired ground transportation services available at airports are described below and include shared-ride door-to-door (D/D) vans, express buses, and multi-stop buses. Rubber-tired transportation services not considered as public transportation are private vehicles, rental cars, airline crew vehicles, taxicabs, and on-demand limousines (Ref 10).

During the past two decades, D/D van service has become available at major airports in the United States. It is now spreading to medium-sized airports and is expected to grow substantially in the years to come. For the inbound trip to the airport, a passenger calls a D/D van carrier in advance to arrange pick-up(typically the vans have a seven-person capacity) at a requested place and agreed time. The passenger's origin may be any point within the carrier's service area, such as a private residence, hotel, office, or military base. Other passengers may already be on board or picked up on the way. The van then takes the passengers to the airport for drop-off at their respective airline terminals. On the outbound trip from the airport, the pattern is reversed and the van picks up passengers bound for the same general area at the curbside of airport terminals. Some passengers may have advance reservations; many are walk-ups. The van then takes the group to the destination area, dropping each passenger at his or her specific destination, and, after the last drop, begins the next cycle. In the spectrum of transportation operations, D/D van service can be classified as a demand-responsive shared-ride operation, inbound, following a few-to-one trip pattern inbound, and a one-to-few trip pattern outbound. Both route and schedule can be considered flexible (Ref 8). The primary distinction between the transportation service offered by taxicabs and D/D vans is the travel time, fare, and the need to share the vehicle with strangers (Ref 10).

On the other hand, express bus service typically operates with limited or no enroute stops. Such services are typically referred to as "airporters" or limousines, although these services primarily use vans or buses. Examples of such services include those provided between airports and the Commercial Business District (CBD) or downtown hotels, destinations outside the metropolitan area, or major tourist destinations. In some communities, the public transit agency operates express bus service between the airport and the CBD (Ref 10).

Finally, traditional multi-stop, line-haul public buses are available at many airports. Such services are publicly operated and provide low-fare, fixed-route service. Typically, this type of service is the least expensive transportation service available at an airport and provides the lowest level of passenger convenience (lacking door-to-door service, baggage handling services, and baggage storage space). Figure 2.1 shows the public transportation market share patterns at large U.S. airports with rubber-tired access modes (Ref 10).

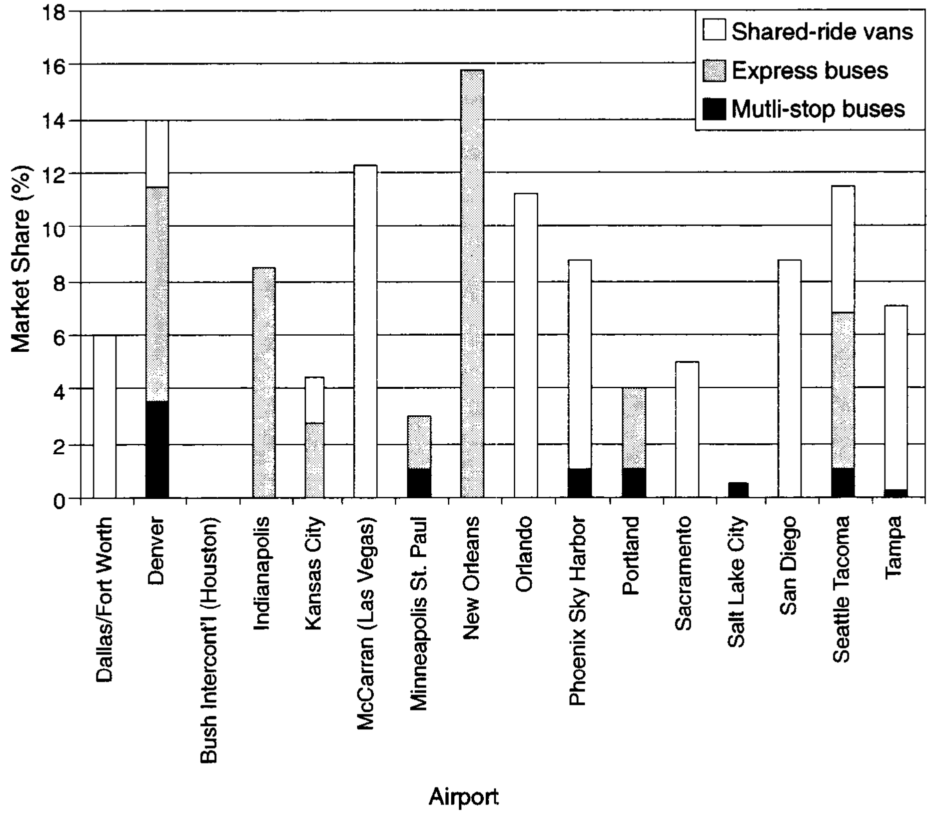


Figure 2.1 Public transportation market share patterns at large U.S. airports without rail service (Source: Ref 10)

Rail Transit Access to Airports

Rail connections to airports can be divided into three basic categories: conventional railway, urban rail rapid transit, and exclusive service. Conventional intercity or commuter railway lines are common at several European airports. These access links consist of special-purpose spur lines that are connected to the existing rail network and are usually oriented to a main station in the central city. On the other hand, rapid transit systems are a coordinated part of the overall metropolitan transit system and thus airport passengers as well as employees have reasonable access to a large portion of the urban area. Finally, one of the most significant technological advances in recent years has been the concept of a high-speed, nonstop train that transports passengers from the airport to the city center and vice versa (Ref 11). With such means of transport, services and vehicles designed specifically for the needs of the airline passenger are provided. In London, both the Gatwick Express and the Heathrow Express rail services are examples of dedicated service, with vehicles designed for the airline passenger (Ref 10).

The first examples of rail access started as shuttle services between the airport and the city center, often the main railway station. For example, the Brussels airport rail link was placed into service in time for the World Exhibition in 1958 and aimed at relieving the increasingly congested local road access to the airport. The concept of the airport rail link then developed as an alternative and a challenge to road transport as a whole. As a result, airport rail stations were fully integrated as part of the relevant suburban and national railway networks. In some cases, the airport vicinity was connected by rail to the surrounding larger cities within the region. This is the case when a stop along the long-distance trains is established at the airport, for example, at Amsterdam, Frankfurt, Geneva, or Zurich. In 1994, the first airport stations fully integrated into the national high-speed rail (HSR) systems went into operation (Paris Charles De Gaulle (CDG) and Lyon Satolas). HSR access serves to extend the airport catchment area for a given acceptable access time (Ref 12).

In most U.S. cities where airport rail links exist, they do not carry a significant percentage of airport passengers, and traffic congestion en route to most U.S. airports continues to worsen (Ref 13). Table 2.3 shows the mode share for rail at five European airports and five U.S. airports. The greater reliance on rail to access European airports is evident in these numbers.

A common characteristic of each successful European rail airport access system is its connection to a wider national system; in many cases, the level of ridership on services to the airport depends largely on the contribution of the market served by the national intercity system, not on the metropolitan market. For example, in Zurich high-quality rail services run every 15 minutes from the airport to Zurich Central Station, which also serves as a rail hub throughout the region. This close interconnection with long-distance services is being emphasized in ongoing planning efforts (Ref 14).

The success of airport rail links, whether in the U.S. or in Europe, depends on two categories of factors, shown in Table 2.4 (Ref 13).

Table 2.3 Comparison of rail mode share for airport access

European Airports		U.S. Airports	
Zurich	34%	Washington National	15% (1987)
Munich	30%	Atlanta Hartsfield	9% (derived)
Frankfurt	29%	Boston Logan	6%
London Gatwick	26%	Chicago O'Hare	5%
Amsterdam Schiphol	25%	Philadelphia	5%

Source: Ref. 13

Table 2.4 Fixed and design factors affecting airport rail links

Fixed Factors	Design Factors
Location of the airport relative to the city	Speed and reliability relative to other access modes
Productions and attractions along the link	Location of airport train terminal
Local cultural factors	Transit fare(s)
Airport characteristics	Parking rates
Ease and availability of connections	
State of local transit	

Source: Ref. 13

Aspects of an airport rail link that are considered permanent or very difficult to change are termed fixed factors while, aspects that are controllable in the context of the rail link planning and design, at least to some extent, are termed design factors (Ref 13). Ridership at airport stations is likely to be greatest in communities that have a transit-oriented population, conveniently located stations, and rail service with reliable and competitive travel times (Ref 15)

Off-Airport Terminals

One method to reduce airport-generated traffic demand on airport roadways and in the vicinity of the airport is to provide satellite parking lots linked to airport terminals with express bus, rail, or ferry services. This link is most often provided via express buses in the United States. However, passengers using such terminals must give their luggage to the bus driver before boarding the bus, reclaim their bags upon arrival at the airport terminal building, and then carry them to the airline ticket counter. A similar process is encountered when passengers return from their trip (Ref 16).

The increase in landside congestion combined with the limitations of satellite parking lots has resulted in a renewed interest in the use of off-airport terminals linked to the airport by bus or rail service. Airports and airlines benefit from off-airport terminals because such terminals could reduce the number of private vehicles and taxis using the airport and the volume of passengers to be checked at the airport. For passengers such terminals could lead to savings in parking costs or eliminate the need to find a ride to the airport. Off-airport facilities allow the possibility of early check-in without the need to spend additional time at the airport (Ref 17).

An off-airport terminal is defined as a facility located away from the airport in which passenger processing activities are provided and that is connected to the airport by a dedicated or shared access system (Ref 18). The notion of off-airport terminals covers a wide array of facilities from those providing almost all the services of the airport to ones that are little more than waiting rooms for bus service. Accordingly, three different types of off-airport terminals are identified: full-service terminals, limited-service terminals, and nonservice or access terminals (Ref 19).

Full-service terminals provide all the passenger services usually available at the airport: ticketing, passenger check-in, and baggage claim. Ideally, such terminals allow inbound passengers to check baggage at the trip origin all the way to the final destination. One alternative would be to have them claim their baggage at the airport in the usual way (Ref 17). When still in operation, the West Side terminal in New York City was a full-service remote terminal (Ref 19).

Limited-service terminals provide only some of the above-mentioned services. The simplest is passenger ticketing, because a travel agent could do it. Provision of baggage check is less common as it requires airline participation, although one airline could handle baggage for others under a joint agreement (Ref 17). An example of a limited-service terminal would be the former downtown terminal in San Francisco (Ref 19).

Finally, nonservice or access terminals do not provide any passenger-handling services. These facilities may be limited to a sheltered waiting area, with such amenities as public telephones and vending machines. More elaborate facilities might include coffee shops, newsstands, or car rental counters (Ref 17).

Off-airport terminals providing baggage check-in and/or claim facilities are in operation in several cities including Hong Kong, London, and Zurich. Airlines once operated off-airport terminals in several cities in the United States including New York, Phoenix, and San Francisco. These terminals have since closed. However, with the renewed interest in intermodal transportation, development of off-airport terminals is being considered in several cities, e.g., Boston, Dallas, and Seattle (Ref 16).

Perhaps the most elaborate system of off-airport terminals is located in Swiss railway stations. Operators of the Swiss railway, in conjunction with several airlines, have implemented the "Fly-Rail Baggage" program at Zurich and Geneva international airports. From any of 116 Swiss railway stations, passengers can check their baggage to almost any destination in the world on most airlines up to 24 hours before their scheduled flight departure time. Passengers can also check in and obtain seat assignments and boarding passes at twenty-three of those railway stations. Moreover, from any origin airport in the world served by the participating airlines, which include Austrian Airlines, Balair/CTA, Crossair, Delta Air Lines, Sabena, Singapore Airlines, Swissair, and Swissair partners, passengers can check their baggage through to their final Swiss railway station (Ref 16).

In order to develop a successful off-airport terminal, several planning issues must be considered. Of those, terminal location is the most important factor. The terminal must serve a large enough market to be viable, and must be far enough from the airport that the travel time to the terminal is short as compared to the total trip to the airport. Where more than one terminal is proposed, the relative location of each becomes critical (Ref 17). In addition, the following key challenges must be addressed to provide for a successful off-airport terminal and associated transportation service between the terminal and airport (Ref 16):

- Security requirements: It is required that all airports and airlines adapt and implement the approved FAA Security Program (mainly addressing passenger and baggage screening).
- Close-out times: There is a minimum preflight time available to passengers arriving at the off-airport terminal for transporting luggage after being checked in at the airport; in addition, passengers must account for travel time between the terminal and the airport.
- Difficulty providing baggage claim: For example, with such a system, who would be liable for lost or damaged baggage? In addition to customer service issues, such as a passenger is met unexpectedly by a friend or relative, currently there is no way to stop checked baggage from going to the off-airport terminal.
- Travel time advantages: The mode of travel between the terminal and the airport must provide reliable and reduced travel times compared to private auto to be attractive

(e.g., if buses can make use of high-occupancy vehicle (HOV) lanes or bus preemption at traffic signals, it would become competitive).

- Availability of parking.
- Airline industry cooperation and support.

Emerging Technologies for Airport Access

The level of emphasis given to various forms of Advanced Traveler Information Systems (ATIS) differs between the United States and Europe. A key difference in policy emphasis is related to the application of ATIS technology to the long-distance trip in general, and the intermodal passenger trip in particular. An intermodal passenger trip is characterized by the use of different modes for the various trip segments from origin to destination. Airport access can be seen as part of a larger, emerging interest in the United States in the development of information programs for long-distance trips, and the application of multimodal "itinerary planning" information technology to those trips (Ref 20).

Most long-distance trips are intermodal in nature; travelers embarking on such trips rely upon the coordination of services from node to node and upon sources of information that can support all segments of the trip. This support in the form of information technology can be used to improve the quality of the trip experience for the traveler (Ref 20). However, a key issue for the providers of airport access services is the dissemination of information about the services. On the other hand, a key issue for the traveler is to learn about the transit options available (Ref 10).

In addition to the use of Intelligent Transportation Systems (ITS) in the form of ATIS to help passengers plan and undertake the long-distance trip by public modes, ITS can be used to help alleviate some problems and hassles associated with searching for available parking spaces at airports. The discussion of emerging technologies for airport access is divided into two parts. In the first part, ATIS for airport access is discussed. The second part deals with Advanced Parking Information (API) systems at airports.

ATIS for Airport Access

Recent literature on ATIS for the long-distance trip has defined three time frames for information dissemination: at the time of trip planning, at the time of trip commencement, and while en route (Ref 10). However, most of the literature about the short-distance trip refers only to a *pre-trip* phase and an *enroute* phase. For the analysis of the long-distance trip, the concept of *pre-trip* needs further differentiation between the needs of the user at the time of reservation and those at the time of trip initiation. A traveler's need for information varies significantly as a function of the timing of the information request (Ref 20).

At the time of trip planning, the intercity air traveler needs information about ground transportation options available to a particular destination simultaneously with the selection of the airline trip (Ref 20). Currently, several implementation activities are underway for a wide array of strategies to disseminate ground transportation options to travelers. Such activities range from total integration of both information and ticketing, to early attempts to provide information on local routes and schedules for travelers in a user-friendly format. The most thorough information integration incorporates the connecting modes data into the actual reservation system used by the airlines, the Computer Reservation System (CRS). Lufthansa German Airlines and the German Federal Railroad (Deutsche Bahn) have pioneered much of the activity in this area during the past decades. For that purpose, in 1998 Lufthansa and Deutsche Bahn announced an agreement to widen the concept of through ticketing between air and rail. Under this relationship, information about travel to several German rail stations from connecting Lufthansa flights appears on the CRS in a form similar to connecting flight information. The concept has also become widely available in the United States. For example, in late 1998 United Airlines (UA) began selling tickets on the Hong Kong Airport Express Rail system. Currently, UA sells through tickets for connections on the French railway system to Lyon to passengers flying from the U.S. (Ref 10).

While full integration of ground/air access ticketing is being undertaken in several markets, lesser levels of information integration and dissemination are also being pursued. In this respect, many public mode service providers are de-emphasizing the use of traditional schedules describing specific routes, and are instead providing trip itineraries describing all segments of the traveler's trip from origin to destination. Transit itinerary trip planners, or software packages that guide the traveler from the point of origin to point of destination, are used in several cities in Europe, and are currently being implemented in the U.S. Higher levels of information integration have been attempted at Amsterdam's Schiphol Airport. The airport's Web site provides the traveler with station-to-station itinerary trip planning for either the domestic or international rail system. This system is dynamic in nature as it provides current information on routes, schedules, and fares; however, it does not provide real-time data about accidents or other incidents that cause delay in the rail system (Ref 20).

Currently, the European Union is considering door-to-door, intercity trip planning across national borders, ultimately covering the entire European Union. In December 1998, the EUSpirit project was launched by a consortium of agencies under the leadership of the Deutsche Bahn. As it stands today, the program is designed to provide itinerary planning from a specific origin address to a specific destination address in the deployment corridor using the national railroads for the long-distance trip segment. The initial corridor ranges from Sweden to Italy (Ref 20).

In the United States, itinerary programs for public transit are being developed under several separate technical and institutional models. In Washington, D.C., the Washington Metropolitan Area Transit Authority, based on its well-developed program of providing information by telephone operator, now provides transit itinerary planning. A system based on the same software is being used in San Diego. In the New York Metropolitan Area, new programs are also being established (Ref 10).

En route information is particularly important for public mode service travelers that rely on connections. While accurate information about departure gate and flight status is considered a given within airports, information to aid the transit user has been slower to develop. However, with the interest in ITS, efforts are increasing to provide en route information to public transit users (Ref 20).

London's Heathrow Airport, which serves as one of the largest bus stations in the United Kingdom, has a computerized information system where television screens are in operation at twenty-two bus departure platforms. This program lists departure times for all national and local bus destinations. Currently, Heathrow is adding the ability to provide real-time information about bus-operating conditions for the public. Another example is the local bus stop at the Geneva Airport, which offers both real-time "next bus" information, and a keyboard-based itinerary planning application. The provision of such services is still rare at U.S. airports (Ref 10).

Advanced Parking Information Systems at Airports

As parking areas at airports near capacity, circulation problems are compounded when travelers are unaware of the location of available spaces. ITS technologies in the form of API systems could help alleviate some of the frustration associated with searching for available parking spaces by first directing passengers to open lots or garages, and then to specific bays. These systems have the potential to benefit the overall operation of parking and access facilities, improve levels of service for airport users, and possibly increase airport revenues (Ref 21).

Table 2.5 includes a partial list of airports in the United States that currently plans to use ITS to manage parking and ground transportation operations (Ref 21).

Air Travel Decision Makiing

While all of the aforementioned factors play a large role in determining congestion levels at and around the airport, an airline trip ultimately results from a set of choices made by a party of air travelers. The choices include the following dimensions: whether or not to take an air trip; the destination of the air trip; time of day to travel; airline; airport; location of departure to the airport; time of departure to the airport; fare category; mode of access; and parking option, if applicable (Ref 5).

Table 2.5 Examples of ITS projects at U.S. airports in 1993

Airport	ITS Initiative	Project Objectives	Status
Denver International	AVI system	Revenue collection, congestion control & ground access transportation management.	Operational
John F. Kennedy	AVI system	Ground transportation management.	Operational
Los Angeles International	AVI system	Tracking commercial vehicles in and out of the airport, and for billing purposes (e.g., courtesy vehicles) using accurate circuit counts.	
Orlando	Commercial billing system	Fee collection.	Operational
Pittsburgh	AVI system	Collects commercial roadway fees and provides shuttle buses access to both the public and employee lots.	Operational
Washington-Dulles	HAR system	The system has 3 transmitters on the access road to the airport to provide parking information.	Operational since 1983
Washington National	Traffic Information System	Provides information on parking availability and road construction at the airport.	Operational since 1982

Source: Ref. 21

To date, most of the literature has focused on two of the trip choice dimensions, namely airport and mode of access, with little attention given to other choice dimensions. The following subsections highlight the most prominent work done in relation to those choices.

Airport Access Mode Choice

One of the first airport ground access applications of the multinomial logit (MNL) model was performed by Ellis et al. (Ref 7). The authors differentiated between trips to and from an airport. The data used in the estimation was from the Washington-Baltimore Airport Access Survey published in 1966, which did not distinguish between residents and nonresidents of the area. The modes considered were private car, rental car, taxi, and limousine. The models used only two variables, cost and time, as well as a mode-specific constant. For each mode and trip purpose classification, passengers going to the airport were found to be more willing to change modes. The authors believe that this is the case because departing passengers fear missing their flight, which typically carries a high penalty. In addition to estimating models for access mode choice, the authors also suggested some ways for improving airport ground access through the use of satellite terminals (off-airport check-in facilities) or by extending rapid transit systems to airports.

Leake and Underwood (Ref 22) developed a model for access/egress mode choice to airports and passenger railroad terminals. The MNL models developed were for Glasgow, Liverpool, London, and Manchester. The only modes considered were private car and public transport, with no further differentiation across public transport services.

Gosling (Ref 23) applied the MNL model to ground access mode choice in the North San Francisco Bay Area. The analysis differentiated between residents and nonresidents but not between business and nonbusiness travelers. The model included the possibility of a Bay Area Rapid Transit (BART) extension to the San Francisco International Airport (SFO). The author noted that the model could be further improved to handle peak and off-peak travel conditions and the effect of baggage on the use of BART, by taking explicit account of the time of departure and number of bags, as well as recalibrating the model for different trip purposes.

In another study of airport access mode choice, Harvey (Ref 5) used data from a 1980 survey of departing air passengers in the San Francisco Bay Area to study the characteristics of access mode choice for local residents. Separate models were estimated for business and nonbusiness travelers. The analysis demonstrated that air travelers are highly sensitive to access travel time and become more so with increasing flight time. Price sensitivities were similar to those for conventional work/trip mode choice. However, the author noted that values of time for airport access appear considerably higher than commonly assumed in transport project evaluation, suggesting that substantial investments in airport access improvements might be justified.

Harvey (Ref 24) extended that work by developing ACCESS, a software package to analyze airport access and competition in a multiple airport region. It simulates air travel patterns by predicting the effects of price and level of service on the behavior of air travelers. Multinomial logit models (MNL) were estimated to capture the effect on access mode choice of the access time and cost, household income, party size, and frequency of airline service. Moreover, ACCESS's database includes air trip information and socioeconomic characteristics for each air travel party. ACCESS then uses those models to determine mode choice and airport choice probabilities per traveling party, in addition to passenger or vehicle flows by mode to each airport. Harvey found that both time and cost had strong effects on access mode choice, but they were not equally important for all classifications of air passengers. As expected, time was more important to the business traveler, while cost was more important to the non business traveler. Other significant variables were also found to exert a differential effect on different air passenger classes. For example, the amount of luggage, gender, and income are more important to non business travelers than business travelers.

Humphreys and Partners (Ref 25) estimated a nested logit model to evaluate ground access services to London to Heathrow Airport. Separate mode share models were developed for four different air passenger segments: UK leisure, non-UK leisure, UK business, and non-UK business. In their analysis, the authors considered seven different modes: British Rail, underground, bus, taxi, coach, park and fly, and kiss and fly. They used data from a 1984 survey administered at both Heathrow and Gatwick Airports, supplemented by a stated preference survey conducted at Heathrow Airport. The models were applied incrementally so that they were used only to forecast the changes in mode shares from existing patterns given a transportation improvement. The authors believed that the "incremental approach" was important because even though the overall modal shares were correctly reproduced in the model, the estimates of the effect of changes might be less reliable (Ref 26).

Finally, Tambi and Falcocchio (Ref 27) used a MNL model to analyze air passenger ground access mode choice with special focus on airport parking. They estimated four separate models based on residence in the region and trip purpose. The airport access modes considered were taxi, limousine, bus, and four different auto-parking options dependent on the parking type (no-parking, hourly lot, daily lot, and remote lot). The following variables were included in the model specification: travel time, travel cost, and a dummy variable for each mode other than drop-off. The results of the study showed that the parking location choice (hourly, daily, or remote) was more sensitive to the terminal access time than to the parking rate. Regardless of trip purpose or origin, users of the hourly lot were highly insensitive to price. Finally, the authors noted that parking rates would have to be increased by at least 50% to cause significant modal shifts.

Airport Choice

Ashford and Messaoud (Ref 28) used a MNL model to determine airport choice in a multi airport region. The most important conclusion drawn from this study is that access time, airfare, and flight frequency cannot be considered equal determinants of airport choice. The trip purpose must be considered in weighing the importance of these explanatory variables.

Harvey (Ref 29) investigated air travelers' behavior in choosing among departure airports in a multiple airport region using MNL models for business and non business travelers. The analysis demonstrated that ground access time and the frequency of direct air service to the chosen destination could account for a large portion of the variation in airport usage pattern. Moreover, it was shown that multi stop direct service is strongly preferred to connecting flights.

Departure Time Choice and Preferred Arrival Time

As mentioned earlier, most of the literature on air travel has focused on mode and airport choice with little or no attention given to the departure time choice decision and the preferred arrival time (PAT). Much of the research on departure time choice has focused on commuter work trips, and to a lesser extent, recreational trips. Work or recreational trips exhibit a more flexible schedule than business air trips.

Mannering and Hamed (Ref 30) investigated commuters' decisions to delay their departure from work to home in an effort to avoid traffic congestion. Data from the congested Seattle metropolitan area were used to estimate a model of the decision to delay homeward departure as well as models of frequency and duration of this delay. As expected, the estimation results suggest that traffic system characteristics dominate the delay choice, with socioeconomic characteristics and the characteristics of the area near the work location playing a lesser role.

Caplice and Mahmassani (Ref 31) examined commuters' PAT at the workplace, use of traffic information, and switching propensity from a commuter behavior survey conducted in Austin, Texas. PAT was modeled using a Poisson regression model, information use as a binary logit, and switching propensity as an MNL choice model. PAT was highly influenced by the lateness tolerance at the workplace. Moreover, it was shown that commuters prefer not to arrive before a given limit, regardless of work start time.

The above studies dealt with the trip departure time choice for the work trip. However, non work travel accounts for about three quarters of the total trips in urban areas and projections suggest that this proportion is likely to increase. Bhat (Ref 32) estimated a joint model of mode choice and departure time choice for urban shopping trips using a nested structure where the mode choice was modeled at the higher level of the hierarchy and departure time choice at the lower level. In modeling mode choice, an MNL structure was used, while an ordered generalized extreme value form was applied to model departure time choice.

Finally, Kelly (Ref 33) estimated MNLmodels for the departure time choice for intercity air travelers making business and social/recreational trips. The results of the models indicated that departure time is affected by day of travel, location just left from, and trip distance. Moreover, it was noted that the departure time for business travel is affected by time constraints whereas social/recreational trips are impacted by convenience and comfort of the traveler.

Summary

This chapter has highlighted several aspects of airport access that are pertinent to the users of the airport as a transportation system, and reviewed previous studies necessary to perform a review of the literature. Literature on landside access, public transportation, off-airport terminals, and emerging technologies was carefully examined. In addition, conducted on air travel decision making and on modeling those decisions were reviewed.

Air travel occurs as a result of individual travelers making individual decisions on how, where, and when to travel. These individual decisions are affected by many factors, as well as by the specific alternatives available for the trip. There has been an abundance of research that has attempted to understand the factors that impact travelers' decisions. These studies helped identify factors that might be incorporated in modeling travelers' PATs at the airport and stated responses to a range of access mode alternatives.

Chapter 3.
Review of Best Practice Case Studies

Introduction

This chapter summarizes the findings of Texas Department of Transportation (TxDOT) Report 1849-2 (Ref 34) by reiterating the strategies of the selected domestic and international best practice case studies. These strategies seek to improve existing planning procedures and processes to meet the unique needs of airport traffic demand for both people and goods. As part of this project, it is necessary to understand those successful practices that are in operation at several airports in the U.S. and throughout the world. As such, practices at several airports are evaluated, providing a starting point to examine their relevance to airports in Texas and how those practices might be adapted to the Texas context.

Airports included in this documentation of best practices were selected as based on a screening process that considered a large number of airports and resulted in the selection of seven: four U.S. and three international airports. Our consideration in the selection process was to include cases where an appreciable level of public transport usage is available.

Domestic Airports

Different communities in the U.S. have adopted different approaches to providing access to vital airports by providing dedicated links to these airports. These links also serve other traffic under restricted conditions that ensure priority service levels to airport-bound users, for example Highway 66 to Washington-Dulles Airport is a special freeway that allows only High Occupancy Vehicle (HOV) traffic in addition to airport-bound vehicles. Several airports in highly congested cities now provide heavy or light rail access to the airport, with terminal points that are more or less conveniently located relative to the terminal.

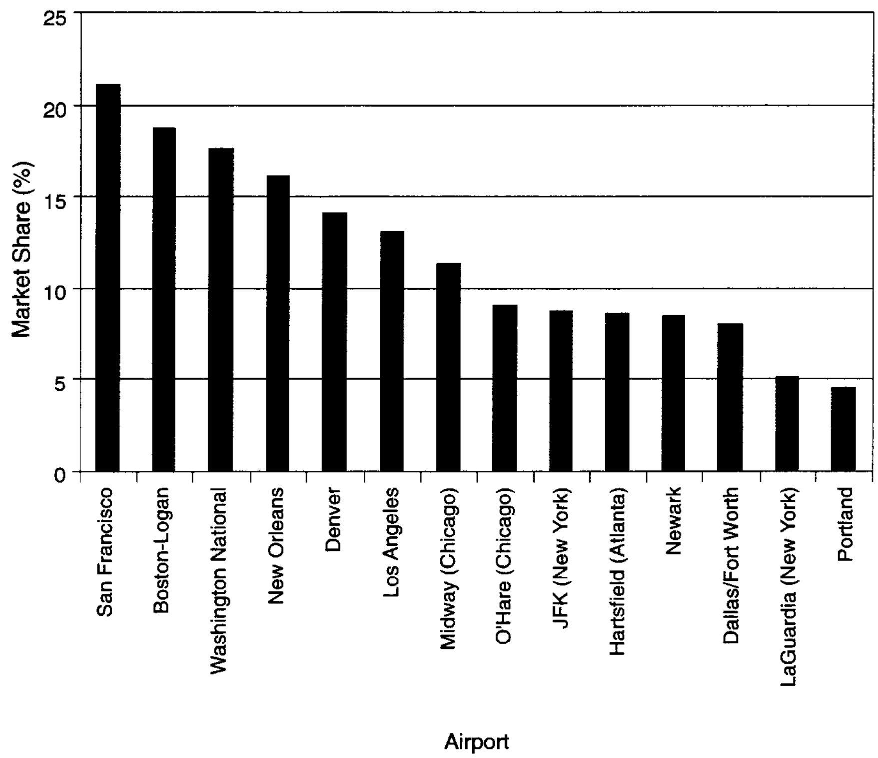


Figure 3.1 Percentage of passengers using public transportation at specific airports (Ref 9)

In this report, a documentation of the range of access modes introduced at four airports around the country is presented. The four are: Chicago O'Hare International Airport (O'Hare), Denver International Airport, Ronald Reagan Washington National Diarport (DCA) , and Dallas Fort Worth International Airport (DFW Airport). The selection of these airports is based on the relative importance of each and their relevance to the project topic. In particular, the percentage of travelers using public transportation to access the airport was noted. This information can be seen in Figure 3.1.

Chicago O'Hare International Airport is one of the largest airports in the world, ranking second during 1999 with 72,609,191 passengers. Two of the airport's most notable features are Terminal 5, the international terminal, and the Airport Transit System (ATS), an elevated, automated people-mover system that transports passengers from the terminals to long-term parking facilities in a matter of minutes. The public transportation market share at Chicago O'Hare Airport is 9%, with rail service used by less than 4%.

Denver International Airport was considered because it is a new airport that might have the potential to achieve high levels of public transport usage. In 1999, its public transportation market share was 14%, with 12% being by bus and the remainder shared-ride vans.

Ronald Reagan Washington National Airport (DCA) is convenient to the entire metropolitan Washington area. With its own stop on Washington's subway, Metrorail, DCA is a short ride from any station on the Metrorail system. This airport has the largest share of rail ridership of any other airport in the U.S., with 14% of all passengers using rail. In addition, its public transportation market share is 17.5% (1999). DCA ranked 65th worldwide in 1999 with 15,020,852 passengers.

Dallas Fort Worth Airport (DFW) was selected because it forms the building block of this project, which focuses on the landside access issues at the major Texas airports. DFW Airport, with 60,000,127 arriving, departing, and connecting passengers in 1999, ranked fifth in the world, in addition to ranking twenty-third worldwide for total loaded and unloaded freight and mail (Ref 35). Moreover, DFW Airport employees and passengers now have a new travel option for getting to work or catching a flight: the Trinity Rail Express (TRE). The TRE has extended its route farther west from downtown Dallas (Dallas Union Station) to Richland Hills, and now serves DFW Airport at the CentrePort/DFW Airport Station. From Monday through Saturday, DFW Airport employees and travelers can ride the TRE train from any TRE rail station into the CentrePort station and ride a free shuttle service from CentrePort into the airport (Ref 36). Nevertheless, it should be noted that DFW Airport was also selected because of the heavy reliance of its passengers on the use of private autos. This would provide an opportunity to address the issue of auto-oriented rather than transit-oriented passengers and attempt a scheme by which we could shift the mode choice towards public transit. Today, less than 4% of arriving and/or departing passengers travel by public means of public transportation.

Foreign Airports

Airport access planning holds considerable importance in many cities of the world, especially because normal congestion levels in these cities preclude reliable arrival at the airport using the regular transportation network and because high urban densities require locating airports very far from the city core. A broader array of modal alternatives is normally available overseas for airport access, with heavier reliance on rail than in the U.S. Recent international experiences and innovations in this regard are reviewed in this report. Airports included in the discussion are: Frankfurt/Main International (Frankfurt) Airport, Hong Kong International Airport at Chek Lap Kok (Hong Kong), and Zurich International Airport (Zurich).

These airports were selected after an extensive review of more than fifteen airports worldwide, and their choice was based on the fact that each offers an example of a particularly successful approach to the access problem. For example, Hong Kong's Airport is one of the most recent airports placed in operation worldwide, and the Zurich airport provides a good illustration of passenger check-in at off-airport stations (Ref 37). Furthermore, these airports demonstrate effective use of public transportation as evidenced by the high percentage of travelers using that mode of access. This can be seen in Figure 3.2.

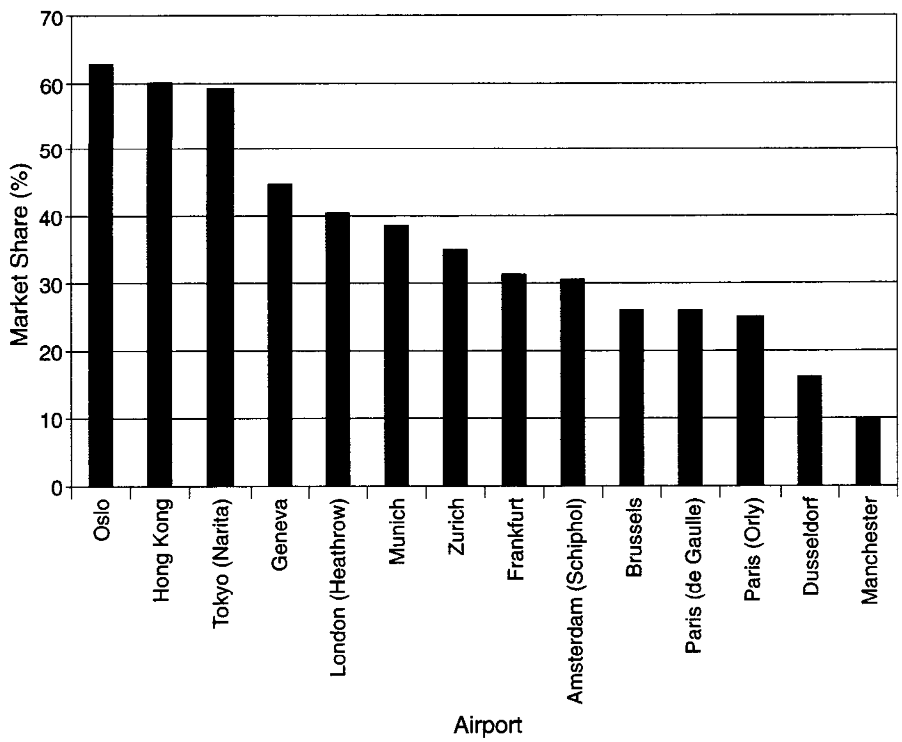


Figure 3.2 Percentage of passengers using public transportation at specific airports (Ref 9)

On peak days, over 150,000 travelers pass through Frankfurt Airport (FRA) on their way to destinations throughout Germany, Eastern and Western Europe, and the rest of the world on peak days. Frankfurt Airport received nearly 46 million passengers (45,869,959) in 1999, making it Germany's leading airport. It has, indeed, evolved into a full-service *intermodal travel port* where air, rail, and road networks are linked in a deliberately planned manner. Frankfurt Airport claims to have "pioneered" the integration of air and rail transportation systems and the opening of the new AIRail Terminal adds a further dimension in that respect, making it one airport with two train stations.

Hong Kong's Airport at Chek Lap Kok was the largest engineering project ever undertaken in the history of Hong Kong. The plan to build the airport was launched in 1989. Upon deciding on a location for the airport, the government and the provisional authority stipulated that the new airport be easily accessible to all users—passengers and shippers alike. The airport was linked to the heart of Hong Kong by almost 40 kilometers of new roads, a dedicated high-speed railway, and landmark bridges, as well as a new town. The railway claims to be the world's first railway built specifically for the purpose of serving an airport (Ref 38). During 1999, more than 83% of those arriving at the airport used a means of public transport for their access trip.

Zurich Airport is a major hub in Switzerland, with a railway station operated by Zurich Transport Federation (ZVV), and integrated into the regional bus, train, and streetcar network. Combined tickets are available for all modes of transportation. Passengers enjoy the opportunity of checking-in at any of twenty-three rail stations in Switzerland. Most airlines allow passengers to make reservations for their preferred seat on the plane at the baggage counter, to check-in their luggage, and to pick up their boarding pass. Therefore, passengers are able to travel without worry about their luggage or losing time at the check-in counter. This check-in is required 24 hours in advance of the takeoff. However, those passengers who do not wish to depart from one of these twenty-three check-in rail stations can make use of another type of service also provided by the ZVV, the Fly-Rail Baggage Service, allows passengers to check their luggage at any of 102 additional Swiss stations. Thus, their luggage can travel by way of the airports of Zurich, Geneva, and Basel to any final destination worldwide. Moreover, from any airport in the world and with any airline, passengers traveling through one of the airports of the previously stated cities can choose to collect their luggage at any rail station in Switzerland (Ref 39).

The previous chapters showed examples of how airports in the United States and around the world have addressed the issue of airport access. It is evident from the discussion that several options are available and in some cases have been very successful in achieving high ridership levels on various means of public transportation.

Airports around the world, particularly those represented in this report (Frankfurt, Hong Kong, and Zurich), have planned for and achieved high public transport modal splits using ground access options not prevalent in the continental U.S. Two prominent options, rail and off-airport check-in facilities, deserve further evaluation.

This chapter evaluates the characteristics of successful implementation of our project airports for ground access by airport rail and off-airport terminal facilities for passenger check-in. The conclusions drawn from the project airports are then applied to airports in Texas.

Airport Rail

Of the public transport modes available at various airports, rail seems to capture the highest mode share at non-U.S. airports. This is the case partly because the available rail links are much more air passenger oriented than those available at U.S. airports. This conclusion is based on a comparison of the performance of the rail links at these airports and the characteristics of the airport rail stations. Table 3.1 serves as a summary of airport rail link performance.

Table 3.1 Airport rail link performance

Airport	Time to CBD (min)	Rail peak headway (min)	Mode Share %	Trains/day	Convenience
Zurich	10	10	42.2	272	Zurich Airport is integrated into the regional transportation network operated by Zurich Transport Federation (ZVV), which offers combined tickets for rail, bus, and streetcar. The airport is connected with all parts of Switzerland and most of the country's large cities and tourist centers.
Frankfurt	11	8-15 (Long distance trains every 1-2 hours)	31	230	Direct connections to and from the airport by ICE and Euro/Inter-City trains to destinations within Germany and neighboring countries. Moreover, rail and air timetables are coordinated. "Rail & Fly" or "Fly & Rail" tickets are available.
Hong Kong	23	8	29.2		Two types of rail services are available: Airport Express and domestic. Off-airport check-in facilities are available at several stations in Hong Kong.
Chicago O'Hare	44	7	4.0		Twenty-four hour service between downtown Chicago and O'Hare.
Washington National	17	3	14.0		

In addition, airport rail stations themselves have special characteristics that determine whether rail will be successful in attracting a high market share or not. Table 3.2 is a summary of the characteristics of the rail stations at the various airports that have been addressed in this project.

Table 3.2 Characteristics of airport rail stations

Airport	Station Location	Distance to Terminal (m)	Convenience
Zurich	Under Terminal B and Parking B		Baggage can be checked in directly or passengers taking their own luggage can use luggage trolleys, which have been designed for use on escalators.
Frankfurt	Near Terminals 1 and 2		Passengers can checkin at the "Check-in T" area, which is a short walk from the rail platforms.
Hong Kong	Directly connected to the passenger terminal		The ground transportation center available at the airport is unique in that it offers convenient access to all forms of transportation.
Chicago O'Hare	Under garage	100	A moving walkway is available for passengers to transfer between the station and the terminal.
Washington National	Across parking lot	500	Poor connections exist between the station and the terminal.

When and Why Rail Works

Transporting passengers to and from an airport would seem to be an ideal role for mass transit. Airports are a significant destination in most cities, making it plausible to justify rail connections to them. (However, in most U.S. cities where airport rail links do exist, they do not transport a significant percentage of airport passengers, and traffic congestion en route to most U.S. airports continues to worsen.) European airport rail links attract a much higher percentage of air passengers (25% - 30%) than U.S. airport links (1% -10%). This might be due to the fact that European passengers are more likely to use rail to reach their final destination (from the airport or, alternatively, from their origin to the airport), whereas Americans are more likely to require a personal vehicle at some point during their trip.

To achieve a high market share for public transportation at an airport, several features are necessary. For example, rail ridership is greater at non-U.S. airports, in part because of the significant reliance on rail in European and Asian cities as the dominant form of public transportation and the extensive inter city (or regional) and intra urban networks. The factors that allow rail to attract large market shares at the European and Asian airports are not directly transferable to conditions in most cities in the United States. Thus, 90% or more of all airline passengers are using private or non public transportation access modes at most airports, including those with rail service. Key factors that might affect the use of rail service include:

- Proportion of airline passengers with trips ending downtown.
- Characteristics of the passenger market (e.g., whether traveling alone or with others, amount of baggage, familiarity with the regional transit system).
- Regional travel time.
- Convenience to walk between station and destination.
- Extensive regional coverage.
- At-airport travel time: Passengers using rail prefer to minimize time required to travel from station to flight gate.
- Frequency of service and associated waiting time.
- Availability of parking at non airport stations.

What the Case Project Airports Are Doing

- Proportion of airline passengers with trips ending downtown. For example, at DCA about 33% of all passengers have trips ending in the downtown area. O'Hare also has large proportions of passengers whose trips end downtown.
- Characteristics of passenger market. Passengers with little or no checked bags are more likely to use rail service. Large family groups are less likely to use rail. DCA has 64% of passengers making business-related trips, while Frankfurt has 44%.
- Regional travel time. The availability of direct service between the airport and downtown, allowing passengers to avoid transfers or multiple stops, is important. Passengers traveling between the airport and downtown encounter six to nine station stops at DCA.

- Convenience to walk between station and destination. Passengers may find using rail service more attractive if their final destination is within easy walking distance of the station, and less attractive (and less convenient) if they must transfer to a second mode (e.g., bus or taxicab) to travel to/from the station.
- Extensive regional coverage. A comprehensive rail network serving a larger catchment area will serve a larger potential market. Therefore, it will provide passengers with more travel opportunities (e.g., those who may wish to leave from their place of work and return to their home) than does a rail system consisting of a single line between downtown and the airport.
- On-airport travel time. The time (distance and convenience) passengers are required to travel between the station and their gate is very important. The average distance between the rail station at O'Hare and DCA is 100 meters and 500 meters, respectively. The availability of baggage trolleys, number of vertical elevation changes (elevator or escalator), and exposure to the elements are some of the measures of convenience that potential users weigh in their mode choice selection.
- Frequency of service. Average waiting times of 10 minutes or less are preferred. The availability of late-night and weekend service is also important. The CTA Blue line train provides 24-hour service between downtown Chicago and O'Hare. The rail peak headways at O'Hare are 7 minutes. DCA has rail peak headway of 3 minutes. The peak rail headways at Frankfurt, Zurich, and Hong Kong are 10 minutes, 8 - 15 minutes, and 8 minutes, respectively.
- Availability of parking at non airport stations. Many transit agencies prohibit overnight parking at stations, discouraging passengers who may wish to leave their car at the rail station for the duration of their trip.

The case studies addressed in this report have served as a sample of U.S. and non-U.S. airports. The non-U.S. airports (Frankfurt, Hong Kong, and Zurich) had most of the successful characteristics, which explains the major difference in modal splits between these airports and the U.S. airports.

Airports in the U.S. have little control over many of the successful characteristics of European and Asian rail access for airports. Most U.S. airports do not have cities and regions with high regional rail usage, nor very high consolidated trip generations. Therefore, it is unlikely that in the U.S. the potential market for rail service will achieve the higher modal splits seen in the project airports. Thus, despite the success of rail service in Europe and Asia, it would appear that airport rail service, particularly investments in new rail service, is difficult to justify on a purely economic basis as few U.S. cities can generate the ridership for successful service.

Off-Airport Terminals

Previous chapters have discussed the methods airports around the world have used in addressing the ground access issues. The options varied from rail terminals directly serving airports, to ground transportation centers that house all transport options, and finally, in some cases, to off-airport check-in facilities, which add to the convenience of traveling by public modes of transportation.

It was noted that some of these airports would not have been able to achieve such high levels of public transport modal splits without relying on a combination of factors. By far, the two most prominent features available are the integration of the airport rail stations in the national and sometimes international networks, and the availability of off-airport or satellite terminals. The high levels of public transportation usage cannot be attributed to satellite terminals alone, rather, it is the integration of rail and off-airport terminals that has motivated this success. Off-airport terminals providing baggage check-in and/or claim facilities are in operation in several cities, including Hong Kong, London, and Zurich. In North America, various airlines once operated satellite terminals in several cities, including New York, Phoenix, and San Francisco. These satellite terminals have since been closed. No satellite terminal providing baggage check-in for multiple airlines for all passengers is now in operation in the United States. However, with the renewed interest in intermodal transportation, development of satellite terminals is being considered in several cities (e.g., Boston, Dallas, and Seattle).

Issues To Be Considered in Developing Off-Airport Terminals

To develop a successful off-airport terminal, a number of planning issues must be considered:

- *Security requirements*: It is required that all airports and airplanes adapt and implement the approved Federal Aviation Administration (FAA) security program (mainly addressing passenger and baggage screening). The U.S. Congress and the FAA plan major changes in the near future for baggage security and screening, which is currently an airline responsibility. These changes are expected to require the screening of all checked baggage, both domestic and international. Currently, only international baggage requires electronic screening in the U.S. Implementation of new procedures will have to be evaluated to determine if the evidence encourages or discourages the likelihood of off-airport check-in terminals.

- *Close-out times*: There is a specified minimum time prior to flight departure by which passengers must have their baggage checked in at the satellite terminal. To achieve the economies of scale, this may require consolidating baggage into batches, which means that the cut off time for off-terminal baggage check-in may be earlier than the minimum travel time between the satellite terminal and the airport. This reduces the attractiveness of such facilities for the busy business traveler.
- *Difficulty of providing baggage claim services*: If baggage claim is provided at the satellite terminal, would each airline have to provide lost baggage claim personnel or would they be consolidated? In addition to customer service issues, there is always the problem that checked bags and passengers will not always correctly match baggage claim locations. Inevitably, through confusion, mistakes, or changes in plans, a fraction of either passengers or baggage will end up arriving at the wrong location.
- *Travel-time advantages*: The mode of travel between the terminal and the airport must provide reliable and reduced travel times compared to private vehicles to be attractive (e.g., if buses can make use of HOV lanes or buses preemption at traffic signals they would become highly competitive).
- *Availability of parking:* If the desire is to attract local residential travelers to the satellite terminal, adequate parking at reduced rates must be provided.
- *Airline industry cooperation and support:* Currently, airlines are responsible for the security and delivery of baggage. Because of the competition between airlines, they would be less willing to have someone other than their own employees handling baggage when they are responsible for it. If an airline industry-supervised company handles the remote terminal, the airlines lose a relative amount of control over level of service issues they would normally, (e.g., late baggage arrival resulting in flight delays). Without support from the airlines, a satellite terminal could not be implemented successfully.

One of the more prominent features that ensures a successful off-airport terminal scheme is the integration of the airport with the comprehensive rail network. In cities in Europe and Asia where off-airport terminals have been successful, rail was an integral part of that success. For example, in Switzerland off-airport facilities are available at 125 rail stations throughout the country. Had they not had a comprehensive rail network there, off-airport check-in services would have been far less successful. The same has occurred in Frankfurt, where off-airport check-in service is to be added soon after major improvements have occurred to the rail network that links the airport to the national and international network.

Although U.S. airports have few of the characteristics of the European airports that have led to successful satellite terminals, there is still some possibility that remote terminals might be responsive to passenger needs and help reduce the ground access congestion problem.

Implications for Texas Airports

A significant problem facing the larger airports in Texas is mitigation of air pollution problems. Houston is in severe non attainment, Dallas could reach severe non attainment levels in the near future, and Austin and San Antonio will be in non attainment in the near future. The severe non attainment designation by the Environmental Protection Agency (EPA) will have considerable influence on the nature and extent of the ground access planning that is expected to take place, and on the types of access alternatives that must be considered. In this respect DFW is in the process of adding commuter rail access to the airport using the Dallas Area Rapid Transit (DART) authority system. This is expected to reduce low-occupancy private automobile trips to the airport and as such help in the reduction of air pollution levels.

At George Bush Intercontinental Airport (Bush Intercontinental), typical ground travel times could be problematic from some parts of the city during certain times of the day. In response to the fact that Houston traffic is at times extremely congested, commuter flights are being flown from Hobby Airport and Ellington Field to Bush Intercontinental, thereby providing intra city air shuttle service. The City of Houston and Continental Airlines, in order to have the airport expansion plans approved through the environmental review process, have recently agreed to reduce the ozone emissions at the airport by 90%. To achieve these reductions, significant improvements in the emissions of ground vehicles and improvements to ground access must be implemented.

San Antonio International (San Antonio Airport) and Austin Bergstrom International Airport (ABIA) share a common problem in that they are both owned by cities that are likely to be designated as non attainment for ozone emissions in the near future. Accordingly, ground access plans that help reduce ozone will be looked at more closely at these two airports. Although the Austin and San Antonio airports are relatively similar in size and in number of passengers, there are some problems unique to each. San Antonio Airport has a higher percentage of international travel, particularly international cargo. With two foreign trade zones on the airport, international cargo is of high importance.

It is likely that procedures and guidelines available at these four Texas airports are generic and are insufficient to address the strategic and tactical planning needs of major airport systems within their entire metropolitan regional context. When Texas airports are compared to the domestic and international case studies presented earlier, it becomes evident that these airports present unique ground access challenges that require coordinated planning. The nature of these issues is such that their scope is not separable from those of general transportation accessibility issues within the entire region of the airport. Airports like DFW Airport have become major growth poles and hubs of economic activity in their respective regions. This role will continue to increase in tandem with the growing importance of convenient air travel for both passengers and goods in the global economy, which is critical to the future economic well-being of the state. Institutional factors involving cooperation and communication among several government and quasi-governmental entities play a considerable role in ensuring an effective planning process that provides for the needs of air passenger and freight travel in the overall mobility of the region.

Chapter 4.
Framework for Analysis of Airport Access

Introduction

This chapter presents the conceptual framework that constitutes the foundation upon which rests the analysis of the airport access problem. In order to properly characterize airport landside access, the framework considers key elements that have direct and indirect implications on airport access. These include the formulation of individual preferences influencing the demand for access, as well as the local and regional impacts of airport access congestion.

At the MPO level, the evaluation of congestion management strategies is currently an area of considerable interest, and planning agencies are searching for appropriate methodological approaches to conduct related assessments. Unfortunately, standard planning tools have well-recognized deficiencies in this regard. Specifically, these tools are static in nature, and hence inappropriate for problems where temporal patterns are essential. Because these strategies are targeted at alleviating congestion as well as ensuring reliable access to airports, the evaluation methodology must be sensitive to the peaking and other temporal characteristics of the demand. Furthermore, current tools typically consider only the highway/private auto mode, which is insufficient for airport access in major metropolitan areas. An intermodal perspective must be adopted in devising an evaluation framework for the various short, medium, and long-term solution strategies for the access problem. To address these deficiencies, it is necessary to understand user decision processes and their effects on access demand, as well as overall network congestion in the immediate vicinity and regional context of the airport.

The following section addresses a component of the framework by examining user-influenced demand for airport access facilities. The third section further develops the framework by describing the underlying methodology of the DYNASMART-IP network modeling tool to study airport congestion at the network level.

Framework for the Demand for Airport Access

Environmental factors, users' attitudes and perceptions, as well as individual and trip characteristics contribute to the formation of individual preferences. These preferences, in conjunction with information accumulated through experience or acquired from other sources, result in a set of decisions made by the individual, which in turn lead to demand for services (Ref 40). Figure 4.1 illustrates the above interactions.

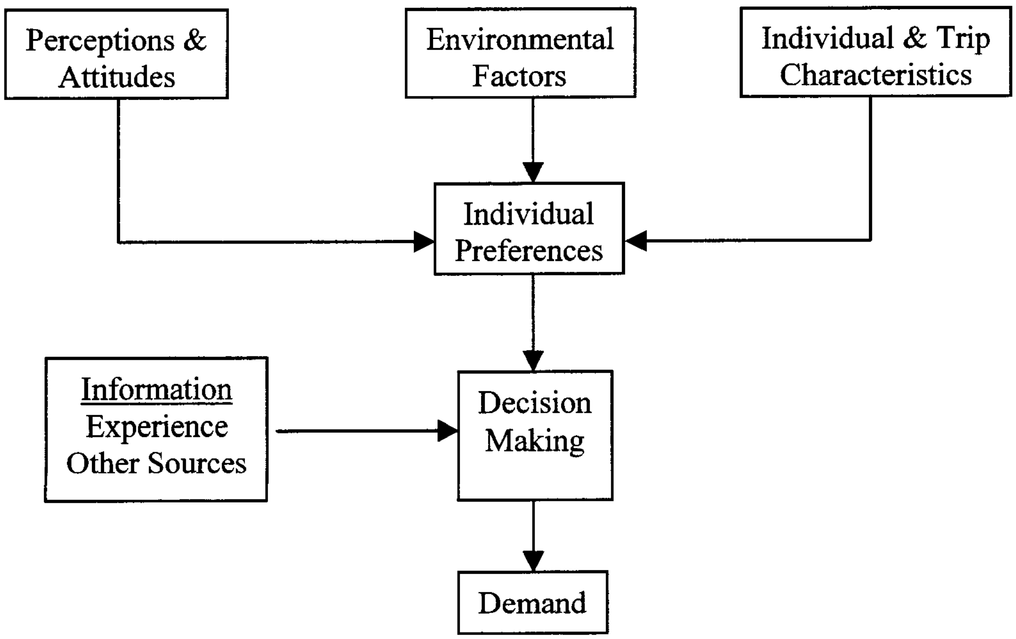


Figure 4.1 Factors and characteristics leading to the demand for airport access

The choices made by users depend on personal and household characteristics. Such characteristics include age and gender of the individual and the number of workers in the household. In addition, trip characteristics such as time of day, parking location, airline, destination, and number of bags are expected to influence the choices made by the user (Ref 29).

The linkage between the attitudes and perceptions of a user and his or her behavior has long been addressed in psychology literature. Individual behavior is affected by intentions, which are in turn influenced by attitudes (Ref 41). For example, when an individual decides to embark on a trip, often the intention would be to participate in an activity. However, different users might have different beliefs and opinions regarding alternate modes of travel because they typically have their own perceptions of characteristics such as comfort, reliability, and convenience (Ref 42).

Available information influences the choices users make. This information is either accumulated through experience or acquired from other sources. Traveler information systems can be of assistance in this regard. It is believed that accurate, timely, and understandable information can contribute to choices that are somewhat better, either for the individual traveler, society as a whole, or both (Ref. 43).

The following subsection deals with the principal classes of users that are considered in the analysis of airport-related travel. This is followed by a presentation of the trip patterns for airport access. The third subsection focuses on the peaking characteristics of the demand for airport access.

Classes of Users and Their Attributes

Trips to and from airports are not only made by air passengers. The airport population is diverse, and the access/egress system must serve the needs of disparate users, namely: air travelers, meeters and greeters, visitors, employees, air cargo personnel, and persons who supply services to the airport. The discussion hereafter first considers air passenger market segments, followed by airport employees, then air cargo.

Air Passenger Market Segments

Air passengers are primarily concerned about dependable travel times, especially as the times relate to flight arrivals and departures. Some of the passengers leave no margin for time delay in their trips to the airport and as such are referred to as *just-in-time* travelers (Ref 10). For most air travelers, missing a flight departure has severe consequences; missing a connecting flight and thus some lost time, or even some additional cost. Indeed, air travelers vary in their sensitivity to ground access costs. Those on business trips are less concerned about access costs than those on non business trips. For some passengers, such as those on leisure trips with low airfare tickets, the cost of ground access may represent a significant portion of the total travel costs.

For each group of air travelers, there tends to be a service or location attribute that dominates their ground access decisions. Typically, air passenger characterization occurs along two dimensions, residency status and trip purpose, which leads to four distinct market groups:

resident business, resident non business, non resident business, and non resident non business. A discussion of the characteristics of each market segment follows.

Resident business travelers are typically the most frequent users of the airport facility, and thus develop patterns of access behavior based on repeated trips to the airport. They are likely to know the most efficient and reliable means of transport to and from the airport. Usually their air trips are short in duration, and such travelers carry little if any luggage compared to non business travelers. While some of these characteristics might make their travel profile favorable for public transportation options, their sensitivity to access time reliability makes them cautious about using public means of transportation. Finally, such passengers are more likely to be traveling to and from the airport at peak arrival and departure times (Ref 10).

Resident non business travelers typically depart from home, travel in large parties, have an appreciable amount of luggage, and have longer stays than resident business travelers. While they may not travel as often as business travelers, they are expected to have some level of information about access to the airport, and may have developed a preferred method of getting there. Depending on the characteristics of their travels, resident non business air passengers will likely be dropped off or picked up at the airport by friends or family, or park in reduced-rate parking facilities. Finally, such travelers are candidates for public transportation access to an airport if the location at which they access the system is convenient and located somewhere between their origin point and the route they would normally take to the airport (Ref 10).

Non resident business travelers are usually either destined for a place of business or a hotel and begin their trips to the airport from the same location. Such places tend to be located in city centers, close to regional attractions or the airport, or in proximity to regional highways. They usually require the kind of flexibility in choice provided by a rental car or taxi. However, they could be users of public transportation when such transportation means are expedient and the trip does not involve multiple stops and transfers (Ref 10).

The fourth and final passenger market consists of non resident non business travelers. These travelers are usually the least informed and most unfamiliar with the access options available at a given airport. Because such passengers may be unfamiliar with the access options available, they will use the most readily available, such as taxicabs or shared-ride, door-to-door vans, and thus are unlikely to use public transportation (Ref 10).

Airport Employee Market Segments

Employee trips to and from an airport are not similar to those generated by other types of office or industrial employment. Such employees have non standard work hours because operations at the airport need to be maintained on a 24-hour basis. A study conducted at Boston Logan Airport estimated that only 60% of all employees commute on an average weekday, and between 30% and 40% of the employees work on Saturdays and Sundays. Moreover, only 25% of weekday employees arrive between 6:00 a.m. and 10:00 a.m., which is the normal a.m. peak period (Ref 1). Flight crews arrive when they are needed for flights and often will not leave the airport until several days later, while non flight crew employees may work on shifts. However, airport employees (airport, airlines, and related businesses) have other characteristics, such as regular travel patterns and familiarity with alternatives, that make their behavior similar to that of regular commuters, and thus amenable to service by conventional transit services (Ref 10).

Airport employees are concerned about dependable travel time, particularly when they must report to work. The 24-hour operation of an airport makes the service hours of any access service very important, because some airport employees must commute at hours not typically covered by regional transit services. In some cases, one leg of the trip might occur within typical commuting hours, while the other leg may be outside those hours, thereby precluding use of public transportation. Airport employees are naturally concerned about the cost of using an access mode because of the repetitive nature of their travel. Airport employees are also concerned about the service frequency (Ref 10).

Air Cargo Operations

Air cargo operations generate employee and delivery trips (e.g., trucks, vans, and other vehicles that transport cargo to and from the airport). There is no commonly accepted trip generation rate for air cargo delivery that applies to all airports, because airlines and airport operators typically report cargo in terms of annual or monthly tons of cargo. Moreover, cargo-handling methods may vary widely and may affect the number of access trips. For example, overnight package services or courier services (such as Federal Express or United Parcel Service) usually assemble large volumes of cargo at off-airport locations and use a few large trucks to transport this cargo to and from their airport terminals. Freight forwarders or agents, who operate at off-airport locations near most international gateways, use similar procedures. On the other hand, a much larger number of access trips per ton of cargo are generated by the small package delivery services operated by air carriers, e.g., Delta Dash (Ref 1).

The conclusion is that airport users differ in their characteristics and behavior. In addition to the attributes of the users, it is important to identify their travel patterns. The following subsection presents the distribution of the origins and destinations of airport users in general and air travelers in particular.

Geographic Distribution of Ground Access Trips

Trip patterns for airport access trips can be separated into on-airport circulation patterns and off-airport trip distribution. The former depends on trip purpose and airport design, while the latter also depends on trip purpose but it is more dependent on regional growth patterns and off-airport facilities that serve the airport. Table 4.1 describes the factors that affect trip distribution patterns for the on-airport and off-airport portions of an airport access trip (Ref 1).

Table 4.1 Factors influencing distribution patterns of airport access trips

Type of Access Trip	**Passenger**	**Employee**	**Visitor**	**Air Cargo**
On-Airport	Proportion of passengers using curbside and parking facilities.	Location of employee parking and transit facilities.	Curbside and parking availability.	Location of air cargo facilities and cargo vehicle entrances to airport.
Off-Airport	Place of residence and employment, tourist attractions, and available access routes and services.	Place of residence and available access routes and services.	Regional demographics and available access routes and services.	Location of air cargo handling agents and clients, warehouses, and industrial facilities.

Source: Ref. 1

Off-airport travel patterns for commercial and private vehicles are often based on the locations of regional population and employment, tourist attractions, hotels, off-airport parking, and rental car facilities. Knowing the distribution of air passenger and employee trip origins is critical to the planning of any successful public transportation service to an airport because passengers from these origins represent a candidate market for the planned service. One important consideration of ground access traveler origins is whether the location is a place of residence (a home-based trip) or one of the many non residential locations (non home-based trips). For home-based trips, the traveler can use the private vehicle as a mode of travel; however, that mode is typically not available for non home based trips (Ref 10).

Non home based origins of airport ground access trips are likely to be concentrated in city centers, business locations, and areas with well-known attractions for visitors. Ground access trip origins of most large U.S. airports are distributed over a wide region (Ref 10).

Temporal Characteristics of Airport Demand

The level of demand accommodated by ground transportation facilities at airports varies by season, day of the week, and hour of the day. An understanding of the temporal nature of this demand is helpful for airport landside management strategies.

The demand for airport services varies by month during the course of a year. For example, during peak holiday travel months, such as November and December, airport parking facility use and landside congestion usually increase compared to off-peak periods. A similar demand pattern is observed during July and August, when vacation travel activity is high. At airports located in states with warm weather resort destinations, such as Florida and Arizona, the peak month may occur during April (Ref 1). Figure 4.2, shows an example of seasonal variations in demand for airport services at Dallas/Fort Worth International Airport (DFW) Airport.

In addition to the seasonal variations in airport demand, facility demands vary by day of the week. For example, peak roadway traffic volumes may occur early or late in the week as business travelers begin or end their trips. As such, the demand for long-term parking facilities may be greatest during the middle of the week (e.g., Wednesday) when most business travelers are away. On the other hand, at airports with a high number of nonbusiness or leisure travelers, peak demands may occur on weekend days (Ref 1). Figure 4.3, shows the daily variations in the number of drop-offs at DFW Airport .

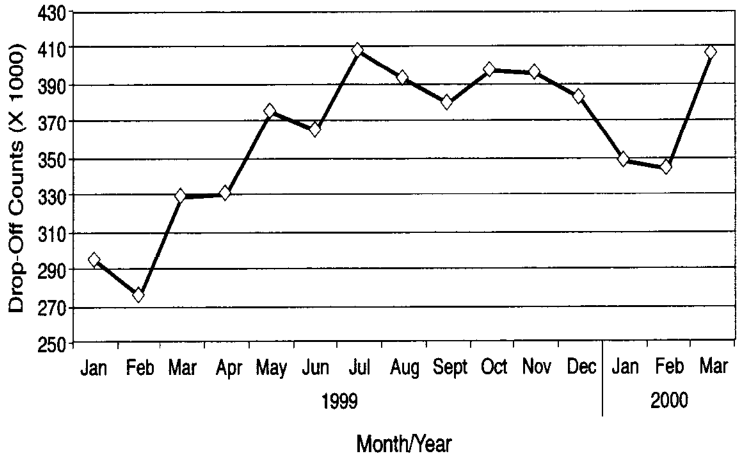


Figure 4.2 Seasonal variations in drop-offs at DFW International Airport

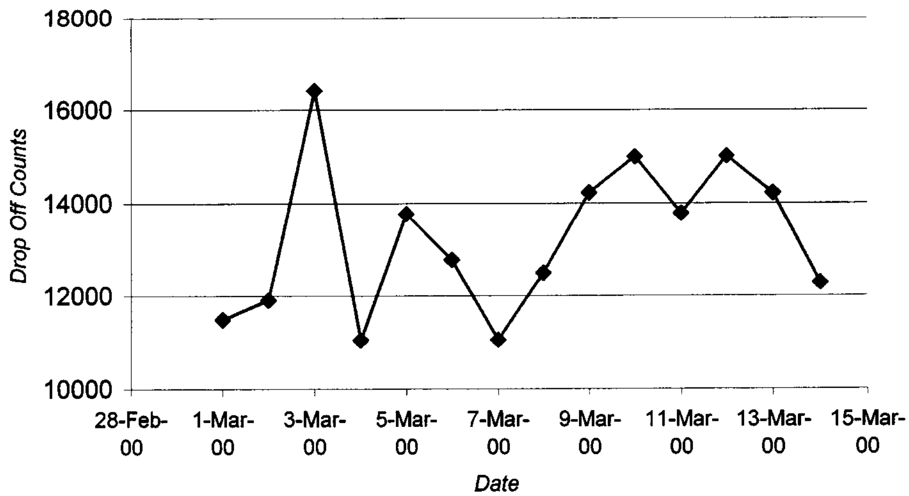


Figure 4.3 Daily variations in drop-offs at DFW International Airport

Finally, facility demands vary by time of day and by type of traffic accommodated by the facility. At large airports, separate roadways and curbsides are often provided to accommodate different passenger activities (e.g., enplaning versus deplaning passengers, international versus domestic passengers). Each of these facilities must be designed to accommodate the activity occurring at that facility during the design period (Ref 1). An example of hourly variations in demand at DFW airport is shown in Figure 4.4.

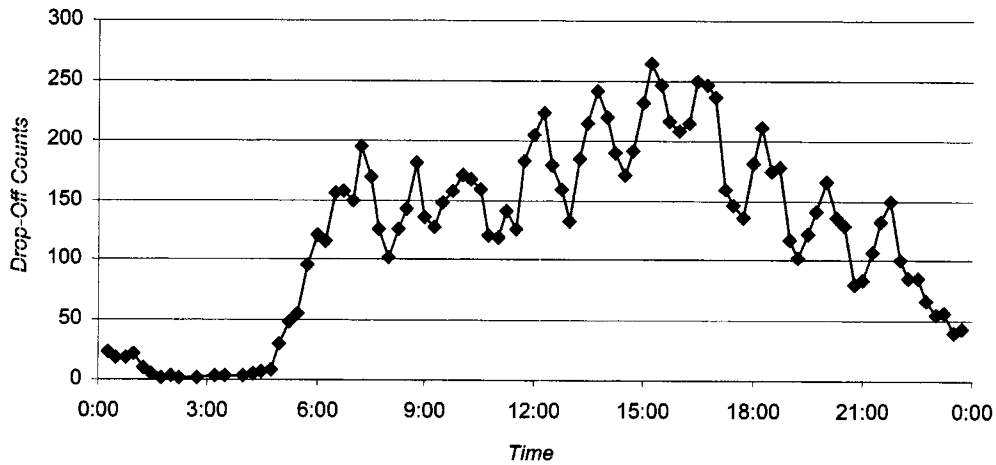


Figure 4.4 Hourly variations in drop-offs at DFW International Airport

Network Assessment of Airport Access Scenarios

In the U.S., rail or light rail access to airports is available at a few airports. Providing alternative ground access options to the airport would relieve congestion on roadways leading to and in front of the terminals. Therefore, it is necessary to test how various elements interact in sharing use of the roadway system and its interfaces with the airport system and available modes. This will allow for diagnosis and identification of the types of problems, their causes, and hence possible short and long-term strategies to alleviate them. To this end a simulation-based approach to the dynamic assignment problem in an intermodal network with an emphasis on airport access underlies the methodology of this work.

Methodological Structure

The model represents several modal networks through a single integrated multidimensional network. Associated with each link are two state vectors for each time interval, respectively representing the number of vehicles of each class on the link, and the associated cost incurred by each class in traversing that link (when the link is entered during the specified time interval). There is no restriction on the number and types of vehicle classes that may be considered in the model. Typical classes of relevance to the study of intermodal networks include autos, trucks, and various types of transit modes. They may also include high-occupancy vehicles HOVs. The associated cost vector provides the principal mechanism for designating certain links for particular classes. For example, a very high cost for a single occupant auto on a certain link, coupled with the actual travel time for an HOV, could indicate a special HOV facility. Similarly, a transit network may be represented to allow both exclusive (e.g., underground rail) or shared right-of-way (e.g., buses). Transfer penalties at major transfer nodes in the network are explicitly modeled. For each traveler, the waiting time until the arrival of the next vehicle that serves the chosen transit line and the parking cost at the park-and-ride facility are considered when evaluating the different travel options.

The model captures explicitly the dynamic interactions between mode choice and traffic assignment in addition to the resulting evolution of the network conditions. It determines the time-dependent assignment of individual trips to the different mode routes in the network, including the corresponding arc flows and transit vehicles loading.

Figure 4.5 illustrates the modeling framework and the different components that are designed to address the above problem requirements. As noted, the model can accept as demand input a file listing the population of travelers, their attributes and travel plans (including origins, destinations, time of departure), and mode choice, if known. However, a more likely way of applying the model is to generate travelers on the basis of prespecified time-dependent Origin-Destination (OD) zonal demands. Each generated traveler is assigned a set of attributes, which include his or her trip starting time, generation link, final destination, and a distinct identification number. A binary indicator variable is also assigned to each traveler to denote car ownership status. In parallel, transit vehicles are generated according to a predetermined timetable and follow predetermined routes. Prevailing travel times on each link are estimated using the vehicle simulation component, which moves vehicles, capturing the interaction between autos and transit vehicles as described later. The model also estimates other measures that may be used by travelers as criteria to evaluate the different mode-route options, including travel distances, parking cost, highway tolls, transit fares, out-of-vehicle time, and number of transfers along the route.

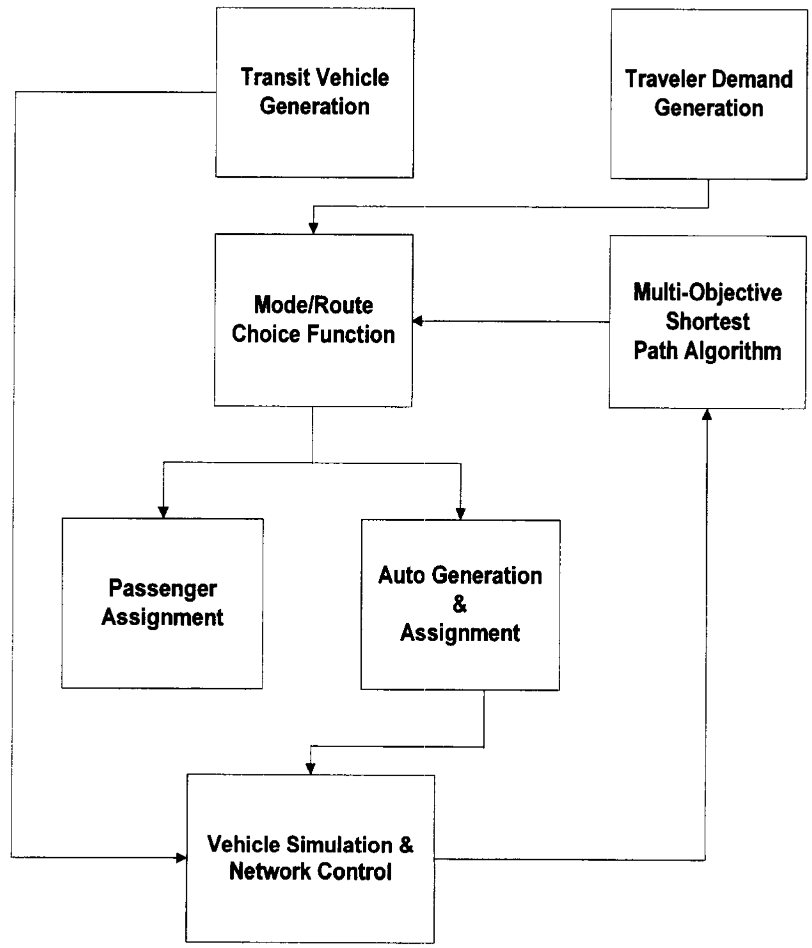


Figure 4.5 DYNASMART modeling framework

A mode-route decision module is activated at fixed intervals to provide travelers with a superior set of mode-route options. The activation interval (usually in the range of 3 to 5 minutes) is set such that the variation in network conditions is captured, while retaining desirable computational performance for the procedure. The route-mode decision module consists of a multiobjective shortest path algorithm designed for large-scale intermodal transportation networks, which is described separately. This multiobjective shortest path algorithm generates a set of superior paths in terms of the set (or a suitable subset) of attributes listed above. Considering a diverse set of travelers' behavioral rules, as well as different levels of information availability and response, travelers evaluate the different mode-route options and choose a preferred one. These behavior rules and response mechanisms are implemented through a behavior component within the model as described in a subsequent section.

Each option represents an initial plan that a traveler follows (unless he or she receives enroute real-time information of a better plan) to reach his or her final destination. This plan describes the used mode(s) and the route to be followed including any transfer node(s) along this route. Based on the available options, a traveler may choose a *pure* mode or a combination of modes to reach his or her final destination.

If a traveler chooses private car for the whole trip or part of it, a car is generated and moved into the network with a starting time equal to its driver's starting time. Each newly generated vehicle is assigned an ID number that is unique to this vehicle. Vehicles are then moved in the network subject to the prevailing traffic conditions until they reach their final destinations or the next transfer node along the prespecified route (in the case of an intermodal trip).

If a traveler chooses a transit mode, he or she is assigned to a transit line so the destination of this passenger is a node along the route followed by the bus line. If no single line is found or if the passenger is not satisfied with the available single line, the passenger is assigned to a path composed of two lines with one transfer node; therefore, the destination of the passenger is a node along the route followed by the second bus. If no two lines are found, the search is continued for three lines with two transfers. It is assumed that no passenger would be willing to incur more than two transfers in his or her trip. Thus, if no path with a maximum of two transfers is available, the trip is determined as infeasible. Given the passenger's origin node, the nearest transit stop along the first line in the passenger's path is determined, and he or she waits until the arrival of the next vehicle that serves that transit line. When a transit vehicle arrives at a certain stop, all passengers waiting for a vehicle serving this specific line board this vehicle (subject to capacity constraints) and head towards either their final destination or the next transfer node along their route.

Upon the arrival of a vehicle (private car or transit vehicle) to a certain destination node, this destination is compared to the final destinations of the travelers on board. If it matches the final destination of a traveler, the current time is recorded for this traveler as his or her arrival time. If the times and/or destinations are different, the traveler transfers to the next transit line in his or her plan. The nearest stop is again determined and the traveler waits for his or her next transit vehicle. The time difference between arrival at the transfer node and boarding of the next line is calculated as the waiting time at the current transfer node for this traveler. This process is continued until all vehicles reach their final respective destinations. If a traveler misses the initially assigned transit vehicle because of late arrival or because the vehicle does not have enough space, the model allows the traveler to replan his or her trip. The available options are regenerated for this traveler, who makes a selection according to the decision process subsequently described.

The model assumes a stochastically diverse set of travelers with different relevant choice criteria and response mechanisms to externally supplied information. The model framework allows implementation of different mode-route choice models that might adequately represent the traveler's behavior. The implemented model could be deterministic or stochastic and could be based on compensatory or non compensatory choice rules. Deterministic models assume availability of perfect information for travelers and that travelers choose the best alternative based on the available information. Stochastic models (e.g., logit form or probit form) on the other hand, take into consideration that information might not be perfect and that travelers may have different perceptions to the supplied information. For the experiments presented in this paper, travelers are assumed to evaluate the different available alternatives either at the start of or along (in case of enroute information availability) their trip based on a deterministic utility function. The multiobjective k-shortest path algorithm with k=3 is used to generate the different attributes for the nondominated paths from every node to every destination. This function combines all the attributes in one generalized cost measure. Travelers evaluate the generalized cost of the different alternatives and choose the one with minimum generalized cost.

Vehicular Movement

The vehicular traffic flow simulation logic in DYNASMART has been adapted to better represent interactions between transit vehicles and autos. The essential features of the traffic flow simulation logic have been described elsewhere, and will not be repeated here (Ref 44 and 45). For completeness, those elements pertaining to transit vehicle simulation in the context of the overall traffic flow simulation are briefly described.

This simulation component is a time-based simulation that moves individual vehicles along links according to local speeds determined to be consistent with macroscopic traffic stream models (i.e., a speed-density relation of modified Greenshield's form is used in this implementation). Every time step, the number of vehicles on each link is calculated using conservation principles; numbers in each class of vehicles in the traffic mix are kept separately. Consistent with the macroscopic logic for modeling vehicle interactions, average passenger car equivalent factors are used to convert each vehicle type to the equivalent passenger car units. The resulting equivalent-car concentration is then calculated for each link and used to estimate the corresponding speed through the speed-density relation. These speeds, updated continually to reflect prevailing conditions, determine vehicular movement on that link.

Queuing and turning maneuvers at junctions are explicitly modeled, thereby ensuring adherence to first-in, first-out principles as well as traffic control devices at junctions. Vehicles that reach the end of the link and are unable to move to a downstream link because of capacity limitations join the back of a queue of vehicles at the downstream end of the link. The physical size of the queue is explicitly represented in the simulation, resulting in the division of the link into a moving part and a queuing part. Vehicles that reach the back of the queue must wait until vehicles ahead of them are discharged. All inflow and outflow constraints that limit the number of vehicles entering and leaving each link under the prevailing traffic control are implemented. The right of way among competing movements is allocated according to the existing control element at every intersection. The outflow constraints limit the maximum number of vehicles allowed to leave any given approach of an intersection, reflecting the available vehicles in queue and outflow capacities of the approach under the prevailing control. The inflow constraints bound the total number of vehicles that are allowed to enter a link. These constraints bound the total number of vehicles from all approaches that can be accepted by the receiving link, which reflects both physical storage consideration and inflow throughput capacity.

If a bus stop is located along a particular link and a bus is stopped at this location, the storage capacity of the link is reduced accordingly to represent the bus-stopping effect. In addition, the inflow and outflow rates of this link are adjusted based on the location of the bus stop within the link. A near-end stop (i.e., located at the upstream end of the link) reduces the link inflow rate while the far-end stop (i.e., located at the downstream end of the link) reduces the link outflow rate. The factors by which the storage capacity and the flow rates are reduced could vary from one complete lane blockage to zero lane blockage in the event of a special-purpose bus bay.

DYNASMART allows representation of complete transit networks, with both exclusive and shared infrastructure. This flexibility is allowed by its integrated multidimensional network representation as described earlier. A set of bus lines is defined in terms of the constituent routes, for which the average headway, stop locations, and vehicle capacities are specified. Different bus capacities may be specified for the different routes. Given a timetable, buses are generated from their origin terminals and moved in the network along their prespecified routes following prevailing traffic conditions. The model tracks all buses along their routes and records their respective arrival times at each stop. Upon arrival at a bus stop, buses are held to allow passengers to board and alight. The number of passengers onboard (bus occupancy) is updated, representing the new bus occupancy, which is also tracked along the vehicles' routes. If a vehicle is full, no passengers are allowed to board and all waiting passengers are reassigned to the next bus or to another trip plan. The model is capable of simulating special bus services, such as express service with limited stops and bus services with different deadheading strategies in which some stops could be skipped under certain conditions. The metro/subway service model is quite similar to the bus service model in most of its features. However, metro vehicles are assumed to have separate right-of-way and hence move with predetermined speeds.

Modeling Considerations Specific to Airport Access

Off-airport terminals are tested as a potential long-term solution for alleviating congestion in the test network. Off-airport terminals are specified by the node and zone of their location. Direct rail service is modeled from the off-airport location to the airport. The high-speed rail is modeled in DYNASMART in a similar manner to an exclusive HOV lane with appropriately specified high-speed transit. By assigning a very high cost for autos traveling in the HOV lane, this precludes cars from choosing the HOV lane to reach the airport. Therefore, the only mode choosing the HOV lane is the high speed (rail). Different combinations of off-airport test locations and rail links are tested to point to a combination that improves the congestion surrounding the airport. Chapter 7 details the DYNASMART inputs and describes the particular inputs needed to model the corresponding transit modes.

Summary

This chapter introduced the conceptual framework of the processes that determine the demand and associated service levels for the airport access problem. The framework is divided into two primary processes: (1) formation of individual preferences and decision making contributing to airport access choices and (2) a network assignment-simulation methodology for examining the access problem at the network level and evaluating alternative intermodal access measures.

Users considered in the analysis of airport-related travel were divided into three principal classes: air passengers, airport employees, and air cargo. Two trip patterns for airport access were discussed: on-airport circulation and off-airport distribution. Moreover, sample variations for airport access by season, day of the week, and hour of the day were presented.

The network simulation-assignment methodology considered different travel modes such as private cars, buses, metro/subway, and HOVs. The model captured the interaction between mode choice and traffic assignment assuming a stochastically diverse set of travelers in terms of their relevant choice criteria.

This framework serves as the basis for subsequent mode choice model development and network-level scenario development.

Chapter 5.
Survey Administration and Exploratory Analysis

Introduction

An airline trip results from a set of choices made by a party of air travelers. These choices include the following dimensions: whether or not to make an air trip; the destination of the air trip; time of day to travel; airline; airport; location of departure for airport; time of departure for airport; fare category; mode of access; and parking option, if applicable (Ref 5). In order to analyze the behavior of air travelers and obtain a better understanding of factors that influence their preferred arrival time (PAT) at the airport and likelihood to use different bus and rail services, surveys were administered to residents of three major airport cities in Texas: the Dallas/ Fort Worth DFW Metroplex, Austin, and Houston. The surveys asked respondents about their last air trip out of the airport, mode used to reach the airport, attitudes and perceptions of different modes, the last air trip that ended at the airport, social and environmental attitudes, stated response to new services, and, finally, some demographic characteristics.

This chapter's first two sections are devoted to presenting a description of the survey and its administration. This description is followed by a discussion of respondent characteristics from DFW, Austin, and Houston. The final section is a description of additional respondent characteristics solely from the DFW survey.

Administration of the Survey

This project addresses the behavior of air passengers when flying from or to airports in Texas. Three different surveys were administered to capture the behavior of travelers from three of Texas's major airports, Dallas/Fort Worth International Airport (DFW) Airport which ranked fifth in the world in 2000 by total passengers (Ref 35); Austin Bergstrom International Airport (AUS); and, finally, Houston's George Bush Intercontinental Airport (IAH), ranking 17th by total passengers (Ref 35).

The surveys were web-based, and responses were solicited by sending e-mails, with a link to the Web site, to candidate respondents. In an effort to obtain e-mail addresses of candidate respondents, specialized software that collects e-mail addresses based on a specified city in a given state was utilized. Additionally, another software that sends bulk e-mail was acquired—in some instances more than 5,000 e-mails were sent within a few minutes (Ref. 46). The surveys were hosted on a Web site operated by Websurveyor, an Internet-based company providing survey-hosting services (Ref 47).

The DFW survey was administered first given the airport's global importance and central role in the present project. Surveys were sent out to residents of Dallas, Fort Worth, and major cities in the vicinity of the metroplex. Moreover, and in an attempt to sample non residents, the same survey was sent out to cities in Texas that are served by direct flights from DFW, such as Austin, Houston, El Paso, etc. In addition, the flight bank of departing and arriving flights from and to the airport was examined to determine the cities most frequently served from the airport and consequently surveys were sent out to residents of those cities. The DFW survey was sent out over a period of 24 days with the first batch of surveys sent on June 12, 2001. A reminder was sent (by e-mail) to recipients who had not responded within 2 weeks of the initial invitation. Determining a response rate for the surveys is not meaningful as several mailing lists were used, and there is no way to know how many of these correspond to real individuals. A total of 254 completed surveys were received from the DFW survey.

A similar approach was adopted for the Austin and Houston surveys. Both were sent out on July 3, 2001. The Houston survey was sent to residents of Houston and neighboring cities expected to be served by IAH. The Austin survey was also sent out to residents of Austin and its neighboring cities, including a targeted group consisting of staff members at the University of Texas. The e-mail addresses of the staff members were obtained from UT's official directory. A total of fifty-two responses were obtained from Houston and 173 from Austin.

Description of the Questionnaire

The questionnaire, included in Appendix A, consists of seven parts described below.

1. Last Air Trip from the Airport

The first part of the survey asked respondents about their last air trip from the airport. Questions pertained to the destination, whether the trip was nonstop or not, time of departure, purpose, number of travelers, number of pieces of luggage, duration, and whether the traveler was a resident or not. In addition, this part included a series of questions about the respondent's preferences for information items and sources.

2. Access Trip to the Airport

The second part of the survey was concerned with the access trip to the airport. Respondents were asked about the type of location they traveled from to get to the airport, time it took to get there, mode used, and length of time prior to the scheduled flight departure that they arrived at the airport. Moreover, respondents were asked to state their preference for how long before the scheduled flight departure they would like to arrive at the airport. Private car passengers were asked about the cost and location of parking, if applicable. On the other hand, public transportation users were asked about the location of boarding the shared ride mode and the mode used to get to that location, number of transfers involved, and, if applicable, length of time prior to the trip that the passenger scheduled for pick up.

3. Attitudes and Perceptions Regarding Alternate Modes

This part of the survey was designed to solicit information from respondents about their attitudes and perceptions concerning the drive-alone mode and the shared-ride mode they have used most frequently or are likely to use if the private car was not available. Questions in this part pertained to how respondents perceive the level of congestion along the route to the airport from their place of residence, their rating of public transportation, and ratings of ten attributes for the drive- alone and shared-ride modes. Respondents were asked to rate these attributes along a five-point Likert scale from *very good* at one extreme to *very poor* at the other.

4. Return Trip Characteristics and Mode Choice

In this part, respondents were asked about the last air trip that ended at the airport. The questions were similar to the ones asked in parts one and two. Respondents were asked about the trip and its characteristics (purpose, origin, luggage, etc.), mode used to travel from the airport to the final destination, and preference for information items and sources.

5. Social and Environmental Views

The fifth part of the survey asked respondents a series of twelve questions about their attitudes concerning social/environmental issues. Respondents' reactions to those statements were measured along a five-point scale from *strongly agree* at one extreme to *strongly disagree* at the other.

6. Stated Responses to New Services

In this part, respondents were presented with three different options for airport access. The first consisted of a new transit service, the second rail service, and the third involved establishing off-airport terminals. In each case, four variations of the service were presented and respondents were asked to indicate their willingness to use the new services using a four-point scale with *very unlikely* (to use the service) and *definitely* (use the service) on either end of the spectrum.

7. Demographics

In the last part of the survey, information about the respondents' demographic characteristics were obtained to study the sample distribution as well as to analyze the effect of these characteristics on the passengers' behavior. Questions in this part were about personal and household characteristics. Personal questions included travelers' hometowns, ages, genders, and education levels. Household questions included household size, number of automobiles available, and number of licensed drivers. In addition, respondents were asked about the purpose of their usual travels and the corresponding frequency of travel, whether they would be traveling alone or with others on those trips, and whether they organize any meetings, and if so, the location of those meetings (close to the airport or not).

Characteristics of Respondents

In this section, an exploratory analysis of the survey responses is presented. The analysis is based on descriptive statistics of responses to the survey questions. The analysis is divided into four subsections. In the first subsection, demographics of the survey respondents are presented. This subsection is followed by a descriptive analysis of mode choice for both the access and return trip. The third subsection addresses the revealed and stated PATs. Finally, the respondents' willingness to use new services is analyzed in subsection four.

Demographics

The last part of the survey provided insight into the socio demographic characteristics of respondents. It included questions on travelers' hometowns, ages, genders, education levels, and incomes. The survey also included questions on household characteristics, such as number of persons living in the household, number of persons with a driver's license, and number of automobiles available. The responses to these and other questions are summarized in Table 5.1.

Table 5.1 Summary of socio demographic characteristics

Characteristic	Categories	Relative Frequencies (%)		
		DFW	AUS	IAH
Hometown		(185)	(130)	(50)
	Texas	86.9	98.5	92.0
	Rest USA	11.9	1.5	8.0
	Not USA	1.2	0.0	0.0
Age		(170)	(132)	(50)
	18 – 21	8.8	0.0	0.0
	22 – 29	22.9	7.6	12.2
	30 – 39	22.4	18.2	16.3
	40 – 49	20.0	35.5	40.8
	50 – 59	17.7	31.1	22.5
	> 60	8.2	7.6	8.2
Gender		(164)	(131)	(47)
	Male	68.3	42.3	65.2
	Female	31.7	57.7	34.8
Education Level		(172)	(132)	(50)
	Grad. High School	1.2	0.8	8.2
	Grad. Technical School	1.2	3.8	0.0
	Some College	19.7	24.2	18.4
	Grad. College	33.7	37.1	40.7
	Post graduate Degree	44.2	34.1	32.7
Income		(168)	(127)	(44)
	< $15,000	3.1	0.8	0.0
	$15,000 – 24,999	3.8	3.2	2.3
	$25,000 – 34,999	1.2	12.6	2.3
	$35,000 – 39,999	3.1	8.7	4.7
	$40,000 – 49,999	6.8	7.8	4.7
	$50,000 – 74,999	21.7	30.7	18.6
	$75,000 – 99,999	23.6	19.7	20.9
	> $100,000	36.7	16.5	46.5
Number of Autos		(161)	(131)	(50)
	0	2.4	3.9	0.0
	1	23.2	33.3	14.3
	2	44.6	50.4	67.4
	3	25.0	6.20	12.2
	4 or more	4.8	6.20	6.1

Note: Values in parentheses are total responses for each question.

Respondents were asked to indicate the city and state or country they came from. If they came from the United States, they were asked the zip code of their hometown. The vast majority of the respondents, 99% to 100% depending on the city, were originally from the United States, and only 1% of the DFW sample respondents were from out of the country. Moreover, it is noted that most of the respondents were actually from Texas. For these surveys, Texas residents dominate the sample (98% for Austin and 92% for Houston), while for DFW about 87% were residents. This is due to the fact that the DFW survey was sent to individuals living outside Texas while the other two surveys were sent to Texas residents only. However, for the Houston survey, the percentage of respondents that are not residents (8%) is higher than what was observed for Austin (1.5%).

Seven age categories were provided for the respondents in the questionnaire. However, one of the seven *(Under 18)* was not selected by any of the three populations. This reflects the manner in which the survey was administered, and adults are the primary ones to have e-mail addresses. The majority of DFW respondents fall in the categories of ages 22 through 29, represented by 23% of the sample, and of ages 30 through 39 (22%). Most individuals, in both the Austin and Houston surveys, lie within the age category of 40 to 49.

It is interesting to note the split between the genders for the two surveys. For Houston, we observe that males dominate the sample (65%), which was similarly observed for the DFW survey. A larger percentage of the DFW survey respondents were male, with 68% of the total representing approximately a 2:1 ratio of male to female respondents. However, for the Austin survey, females dominate the survey (58%). This might be due to the fact that UT staff members were targeted in the Austin sample, resulting in a more balanced sample.

Respondents were asked to report the highest level of education they have completed. Table 5.1 confirms that there seems to be a bias toward better-educated individuals; for all three surveys, more than 70% of the individuals in the sample reported that they have been to graduate school or have a post graduate degree. This very high rate of well-educated respondents reflects the sampling technique, as well as a well-known response bias toward better-educated individuals. Another common bias is toward higher-income respondents. In this case, more than half of the DFW sample, about 60%, reported earning $75,000 or more per year per household. On the other hand, the reported income level from the Austin survey is more moderate than that reported in the Houston (or DFW) survey, with 34% versus 67% reporting an annual household income of $75,000 or more. This may again reflect the larger participation of UT staff members in the Austin sample. However, such values for high-income earnings are typical for air travelers. In the 1995 Metropolitan Transportation Commission (MTC) Airline Passenger Survey, approximately 53% of San Francisco's travelers reported earning $75,000 or more per year per household (Ref 33). A similar yearly household-income figure (56%) was obtained from the "1998 SFO Air Passenger Ground Access Survey."

Another question pertained to the number of automobiles available in the respondent's household. In all surveys, the highest percentage of individuals indicated that they own two cars. However, it should be noted that for these two surveys the percentage of individuals who reported owning three or more cars (Austin-12%, Houston-18%) is much less than those reporting the same from the DFW survey. About 45% of the DFW sampled individuals indicated that they have two autos, while nearly an equal percentage reported owning one or three cars (24%).

Finally, respondents were asked to report how frequently they travel, the usual purpose of those trips, and who would typically accompany them on those trips. Moreover, they were asked whether they organize meetings or conferences, and if they do whether those meetings/conferences are organized near the airport or elsewhere. Table 5.2 summarizes the responses to those questions.

Table 5.2 Summary of respondents' characteristics

Characteristic	Categories	Relative Frequencies (%)		
		DFW	AUS	IAH
Frequency of air trips		(168)	(129)	(50)
	< 1per year	7.7	9.3	8.2
	1 – 2 times per year	18.5	42.6	24.5
	3 – 4 times per year	37.5	37.2	42.9
	1 per month	16.7	7.8	12.2
	> 1 per month	19.6	3.1	12.2
Usual trip purpose		(172)	(136)	(49)
	Work related	51.7	27.2	46.9
	Visit friends/relatives	25.0	38.2	30.6
	Leisure	21.6	28.7	18.4
	Other	1.7	5.9	4.1
Persons accompanying		(172)	(132)	(50)
	Alone	55.8	43.9	46.9
	Household members	25.6	43.2	34.7
	Co-workers	9.9	7.6	10.2
	Friends/relatives	8.7	5.3	8.2
Meetings & their location		(168)	(122)	(48)
	Don't organize any	75.0	76.2	65.9
	Near airport	5.9	2.5	6.4
	No near airport	19.1	21.3	27.7

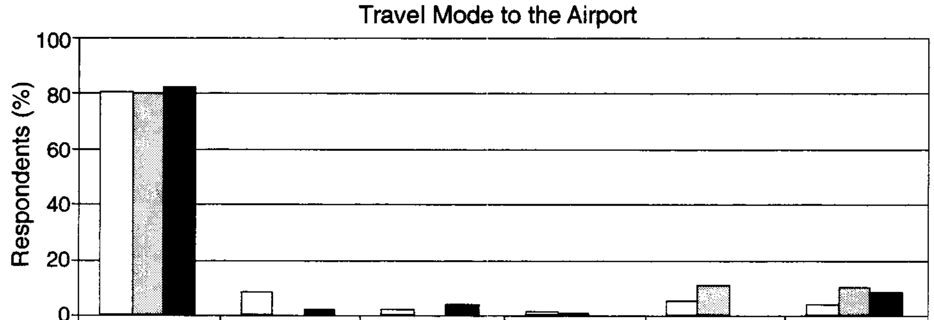
Note: Values in parentheses are total responses for each question.

As noted, most of the DFW respondents travel three to four times per year (38%) and about 52% of those trips are for work-related purposes. The frequency of air trips for the Austin respondents is less than that for the Houston or DFW respondents. Most Austin respondents (43%) reported traveling once or twice per year while those of Houston reported three to four times per year (43%). Moreover, the percentage of respondents who reported traveling once or more per month is approximately twice as much for Houston (25%) as it is for Austin (11%). Most respondents from the Austin survey travel to visit friends or relatives (38%), while those from Houston and DFW mostly travel for work-related purposes. In that respect, Houston's respondents are more comparable to those from the first survey (DFW) as they are to those from Austin. Respondents from all three metropolitan areas are typically either travel alone (44% - 55%) or with another member of their household (26% - 43%). Finally, the majority of the respondents indicated that they do not organize any meetings/conferences. However, if meetings were organized, they would not be held at or near the airport (19% - 28%).

Access and Return Trip Mode Choice

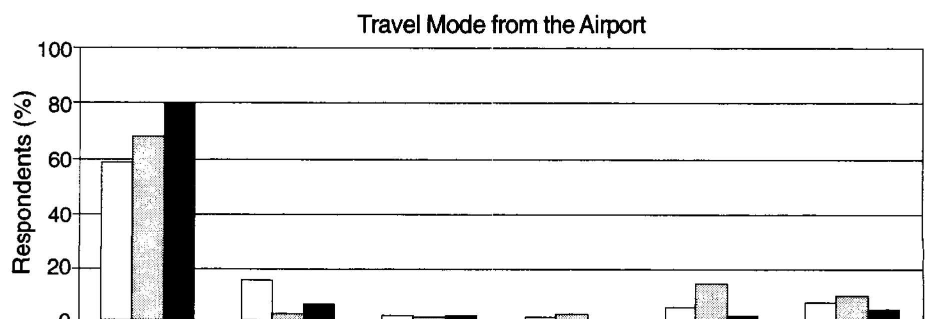
Of particular interest in this project is the mode used by passengers to access and egress the airport, respectively. Figure 5.1 presents the distribution of transportation modes used by respondents to access the airport. By far, private cars account for the highest market share of access modes (80% across all samples). Comparatively, respondents rarely used other modes such as door-to-door vans, buses, or hotel shuttles.

The distribution of transportation modes used by respondents to get to their final destination from the airport is shown in Figure 5.2. Similar to the access trip, the market share seems to be dominated by the private car, accounting for about 57% of DFW respondents—admittedly less than what was observed in the former case (80%). This could be due to the fact that some of those traveling to the airport might be non residents and thus have no means of driving a car from the airport. This might also explain why in this case rental cars account for about 15%, as opposed to 8% in the previous case. Moreover, and similar to the access trip mode choice, respondents rarely used other modes such as door-to-door vans, buses, or hotel shuttles. However, door-to-door van usage appears to be more popular in Austin than in DFW or Houston (to the limited extent reflected in the small samples available). The opposite applies to the limousine, which has a meaningful market share in Houston but did not register in the Austin responses. Like the DFW sample, rental cars capture a higher market share for the return trip as opposed to the access trip. Public transportation has an essentially negligible market share.



	Private Car	Rental Car	Hotel Shuttle	Public Trans.	D/D Van	Taxi
□ DFW	80.00	8.00	2.00	1.00	5.00	4.00
▨ AUS	79.40	0.00	0.00	0.70	10.30	9.60
■ IAH	82.40	2.00	3.90	0.00	0.00	7.80

Figure 5.1 Distribution of modes used to access the airport

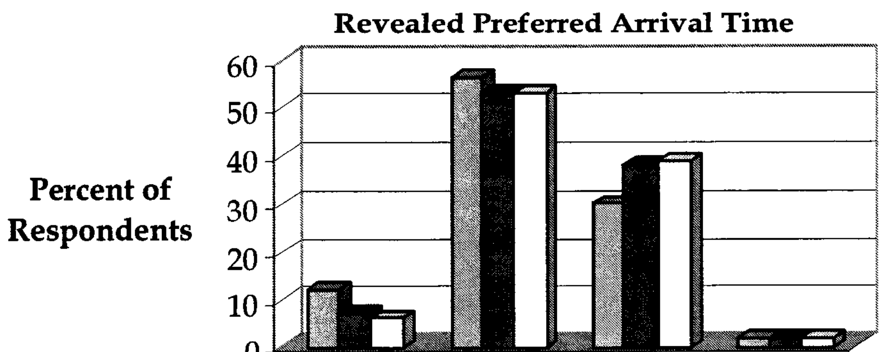


	Private Car	Rental Car	Hotel Shuttle	Public Trans.	D/D Van	Taxi
□ DFW	58.00	15.00	2.00	1.00	5.00	7.00
▨ AUS	67.70	2.30	1.50	2.30	13.80	9.20
■ IAH	80.00	6.00	2.00	0.00	2.00	4.00

Figure 5.2 Distribution of modes used to egress the airport

Preferred Arrival Time and Stated Responses to New Services

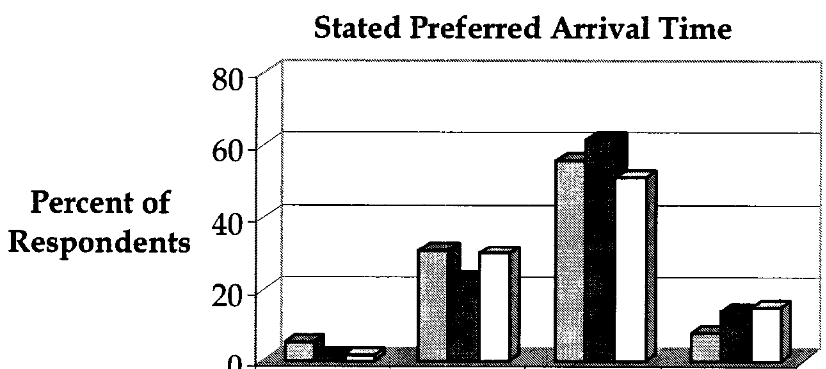
The revealed and stated PAT for DFW, Austin, and Houston respondents is shown in Figures 5.3 and 5.4, respectively. The results for the revealed PAT from both the IAH and AUS surveys are practically the same and very similar to those obtained from the DFW survey. From Figure 4.2, we note that in all samples more than 50% of the respondents indicated that they arrived 30 minutes to 1 hour before their scheduled flight departure. This is expected as most of the trips the respondents were taking were domestic rather than international (80% domestic), which require earlier check-in times. In all cases, greater than 30% of the respondents indicated that they arrived 1 to 2 hours prior to their flight departure, and only 2% indicated more than 2 hours. Interestingly, about 12% of the DFW travelers arrived with less than 30 minutes to spare



	< 30 min	30 min - 1 hr	1 - 2 hrs	> 2 hrs
DFW	12	56	30	2
AUS	7	53	38	2
IAH	6	53	39	2

Figure 5.3 Revealed preferred arrival time

For the stated PAT, it was observed that most respondents in both cities would allow for a buffer of 30 minutes to 1 hour. Moreover, 36% of the DFW travelers indicated that they would allow for 30 minutes or less prior to the scheduled flight departures, while for Houston that figure drops to 32% and for Austin even further to 24%. Interestingly, 56% of the DFW travelers would like to have 30 minutes to 1 hour to spare if they did not have to worry about traffic/parking, which is similar to the percentage of travelers that actually arrived at the airport with that amount of time to spare. However, the 30% of DFW travelers indicating previously that the PAT was between 1 to 2 hours dropped to only 8%. Moreover, when only 12% of the DFW sample said that they arrived at the airport less than 30 minutes before the flight, 36% indicated that (provided traffic/parking was not a problem) they would like to arrive 30 minutes or less before, with 5% of the total number of respondents even indicating that they would like to arrive about 10 minutes prior to their flight departure at the airport. A similar gap may be seen in both the Austin and Houston samples. Models that relate these values to the tripmaker's characteristics and attributes of the trip context are presented in Chapter 6.



	10 min	10 - 30 min	30 min - 1 hr	1 - 2 hrs
DFW	5	31	56	8
AUS	1.5	23	61.5	14
IAH	2	30	51	15

Figure 5.4 Stated preferred arrival time

Willingness To Use New Services

In this part of the survey, respondents were presented with three different options for airport access. The following tables present a description of the three different services and their variants. Table 5.3 presents the specific characteristics of the hypothetical new transit services. In general, this service is composed of a new transit service, which serves an individual's home area to the airport with a travel time 15 minutes longer than his or her current travel time.

Parking will be made available at the transit terminals for a flat rate of $2/day. The buses will be in operation from 5 a.m. until midnight with a one-way and round-trip fare of 50 cents.

Table 5.3 Specific characteristics of the proposed transit service

Service No.	Freq. during rush hour	Stop location from home	Change in airport parking rate
1	Every 20 min	15 min drive	0
2	Every 10 min	15 min drive	0
3	Every 20 min	10 min drive	0
4	Every 20 min	10 min drive	+ $3/day

The next proposed service involves providing rail between the airport and downtown Dallas and Fort Worth. Parking will be provided at the rail terminals for a flat rate of $2/day and the trains will stay in operation from 6 a.m. until midnight during weekdays and until 2:00 a.m. on weekends. Moreover, the trip will be 10 minutes shorter than what a typical traveler experiences to reach the airport. Table 5.4 presents the specific characteristics of the hypothetical new rail services.

Table 5.4 Specific characteristics of the proposed rail service

Service No.	Freq. during rush hour	Fare	Change in airport parking rate
1	Every 30 min	$3 1-way and $5 round trip	0
2	Every 30 min	$2 1-way and $3 round trip	0
3	Every 15 min	$3 1-way and $5 round trip	0
4	Every 30 min	$3 1-way and $5 round trip	+ $3/day

The third and final service involves establishing off-airport terminals in downtown Dallas and Fort Worth. From these terminals, vans carrying up to fifteen passengers will be used to transport the passengers to the airport. The total trip will not be more than 15 minutes longer than what a typical traveler currently experiences to reach the airport. Table 5.5 presents the specific characteristics of the hypothetical new service.

Respondents' stated willingness to use the proposed services is presented in Figure 5.5. For presentation purposes, only individuals stating that they probably or definitely will use the service were included.

Table 5.5 Specific characteristics of the proposed off-airport terminals

Service No.	Fare	Parking charge at terminal	Baggage check in provided at terminal
1	$15 1-way and $25 round trip	$2/day	No
2	$12 1-way and $20 round trip	$2/day	No
3	$15 1-way and $25 round trip	0	No
4	$15 1-way and $25 round trip	$2/day	Yes

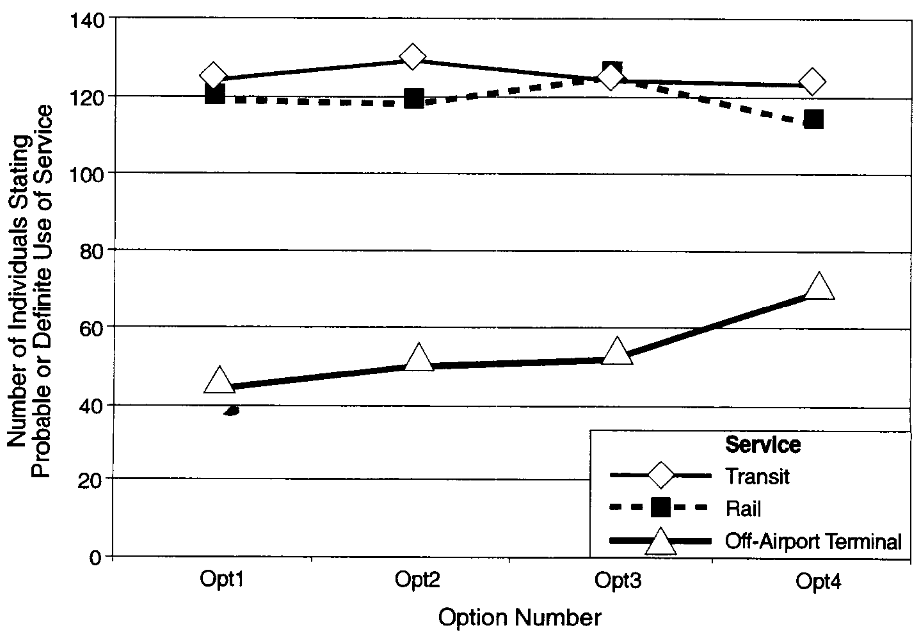


Figure 5.5 Profile of willingness to use new services (DFW)

It is noted from Figure 5.5 that most of the respondents are not enthusiastic about the off-airport terminal option. This might be due to the fact that the suggested locations of the terminals were in downtown Dallas and Fort Worth. Because an appreciable percentage of travelers start their trip to the airport from the suburbs rather than from the downtown area, they might not be particularly keen about the idea of driving downtown before starting their trip to the airport. On the other hand, travelers were as likely to prefer transit or rail but with a slight edge for transit. The service type most preferred by respondents is the second option, transit service. Moreover, they were as likely to choose the third option in both rail and transit. In fact, 125 respondents indicated that they would probably or definitely choose rail service, while 124 respondents indicated the same about transit service.

From Figures 5.6 and 5.7 and similar to what was observed for DFW, most of the respondents are not enthusiastic about the off-airport terminal option. Moreover, in this case (Austin and Houston), it was clear that travelers favored transit over rail, while in the first survey travelers seemed to be as likely to choose either rail or transit. In the Austin case, and again similar to Dallas, the service type that respondents favored was the second option, transit service. On the other hand, the Houston respondents favored equally the third and fourth transit options.

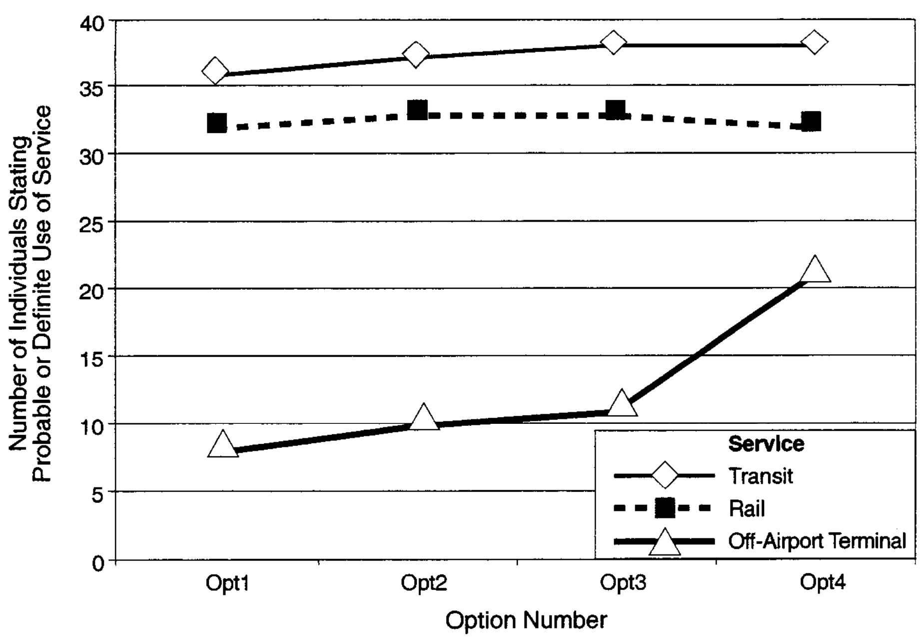


Figure 5.6 Profile of willingness to use new services (Austin)

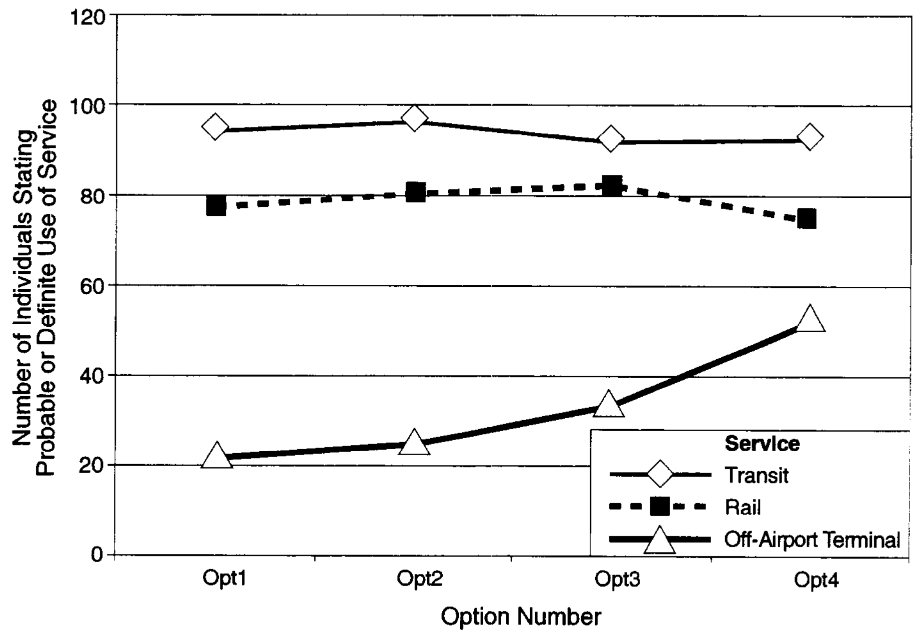


Figure 5.7 Profile of willingness to use new services (Houston)

Respondent Characteristics Specific to DFW

Owing to the early administration of the DFW survey as well as the large number of respondents, it was possible to cull additional information from this sample. The additional information obtained relates to information preferences of airport users and attitudinal measures regarding perceived congestion, as well as public transportation.

Information Items and Sources

As mentioned previously, respondents were asked about information items and their sources. Table 5.6 presents the information items obtained by respondents, the sources they used to obtain this information, their preference for information items, and their preferred means of obtaining it. As noted, most respondents that did use information obtained a map of the city that they were going to (6.5%) and about 3.8% of the respondents indicated that they obtained a transit schedule or parking information.

The most commonly used information sources were the Internet and friends or relatives. As expected, electronic kiosks, TV, and radio were not frequently used as information sources.

Respondents were asked about the primary types of information they would like to obtain when traveling, and the primary sources from which they would like to obtain this information.

The most important information items that respondents indicated they would like to obtain are delays on specific routes, city maps, shortest route to the airport, and terminal congestion. Travelers preferred traditional information sources such as the Internet and friends or relatives when obtaining travel information. Approximately 40% of respondents stated they preferred the Internet and about 15% stated they preferred to ask a friend or relative. Telephone information lines and television were selected by 13% and 9% of respondents, respectively. Few respondents selected information sources such as electronic kiosks, yellow pages, and transit schedule books.

Table 5.6 Information items and sources (departure trip)

Information Item	**Actually obtained** *% of Respondents*	**Desired** *% of Respondents*
Transit schedule	3.8	14.1
Parking info.	3.8	17.8
City map	6.5	22.7
Weather info.	2.7	16.8
Other	2.2	3.8
Shortest route to airport		21.1
Delays on specific routes		27.6
Terminal congestion		21.1
Total number of responses	185	185
Source	**Consulted** *% of Respondents*	**Preferred Source** *% of Respondents*
Yellow pages	0.5	2.2
Internet	6.5	39.5
Guide book	0.5	6.5
Electronic kiosk	0.0	5.4
Radio	0.5	7.6
Television	0.0	8.6
Telephone info. line	0.5	13
Transit schedule book	1.1	4.3
Friends/relatives	3.8	15.1
Other	1.6	2.7
Total number of responses	185	185

As shown in Table 5.7, there is no major difference between the preferences of passengers who were flying out of the airport and those flying into the airport. However, it was noted that the percentage of passengers who indicated desired information items and their corresponding sources was higher for the return trip than for the departure trip. That could be because some of those travelers might be non residents who are unfamiliar with the area and thus would like to get information that would reduce the stress and anxiety of travel. Moreover, it was noted that the information sources preferred the most are those sources that can disseminate information even before the trip begins, such as the Internet, friends or relatives, and the radio.

Attitudinal Measures

The survey included questions about respondents' attitudes and perceptions concerning the level of congestion along the route to the airport from their residence as well as the quality of public transportation.

Respondents' perceptions of the level of congestion along the route to the airport from their residence is presented in Figure 5.8. It is noted that the highest percentage of respondents believes that the route is slightly congested (44%), while those believing that the route is extremely congested account for 10% of the respondents. It is interesting to note that approximately 14% believe that it is not congested at all.

Table 5.7 Information items and sources (arrival trip)

Information Item	Actually obtained *% of Respondents*	Desired *% of Respondents*
Transit schedule	5.9	25.4
Parking info.	3.8	27.6
City map	8.6	42.7
Weather info.	3.8	41.1
Other	3.8	8.1
Shortest route to destination		43.2
Delays on specific routes		53.5
Total number of responses	185	185

Source	Consulted *% of Respondents*	Preferred Source *% of Respondents*
Yellow pages	3.8	6.5
Internet	9.7	72.4
Guide book	2.2	11.9
Electronic kiosk	0.5	13.0
Radio	0.0	21.1
Television	1.1	15.1
Telephone info. line	3.2	16.2
Transit schedule book	2.2	7.6
Friends/relatives	3.2	29.7
Other	4.3	4.3
Total number of responses	185	185

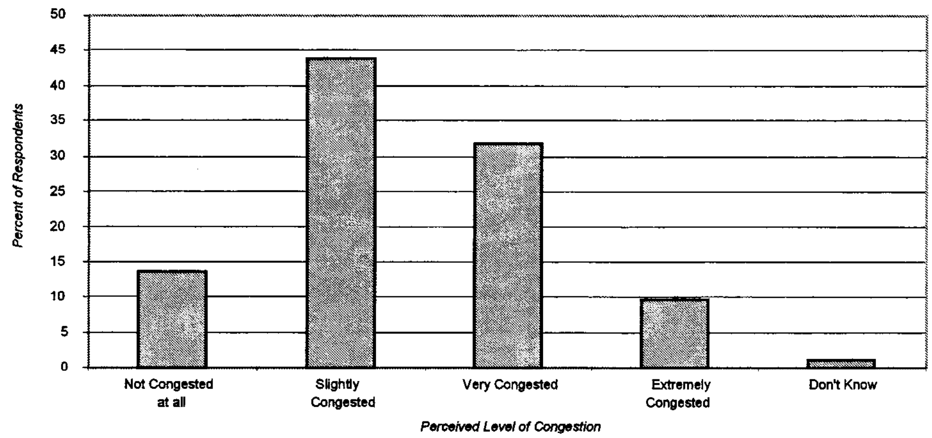


Figure 5.8 Respondents' distribution based on their perception of the level of congestion

Moreover, respondents were asked to rate public transportation between their residence and the airport. The results are presented in Figure 5.9. Most respondents believe that public transportation serving their home area to the airport is non-existent (33%), while 17% are unable to rate it. It is worth noting that about 24% of the respondents believe that public transportation between their home and the airport is fair or better.

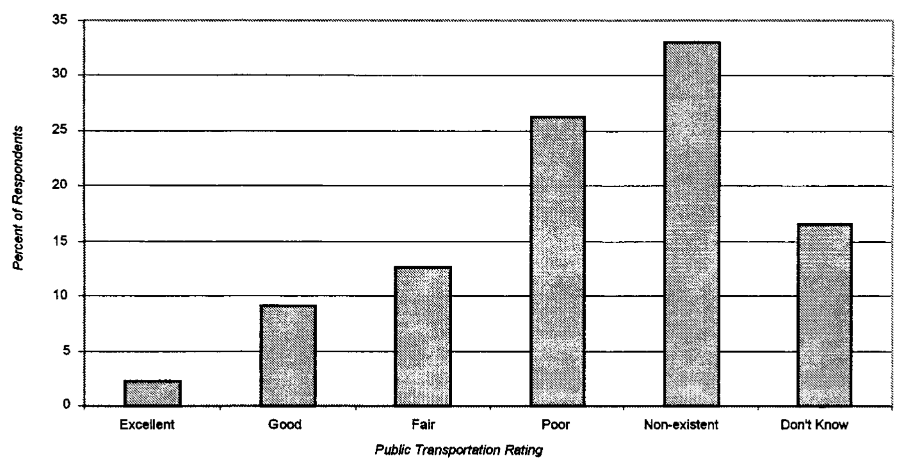


Figure 5.9 Respondents' distribution based on their rating of public transportation

Summary

This chapter has presented an exploratory analysis of revealed and stated preference data obtained from air passenger surveys administered to residents of three major airport cities in Texas: theDFW metroplex, Austin, and Houston. From the results of those surveys, the revealed and stated preferences for travelers' airport access mode choice and PAT at the airport were the subject of additional analysis.

The results from the revealed preferences for the mode choice indicate that private cars account for the highest market share for access modes. This was observed in all three cases (DFW – 80%, Austin – 79%, and Houston – 82%). On the other hand, passengers' stated responses to the hypothetical new services indicate that off-airport terminals are not likely to be used by a large percentage of the traveler market. It should be noted that travelers were equally likely to prefer bus or rail with a slightly higher preference for transit.

The revealed and stated preferences for the PAT were similar. It was observed that most travelers allowed between 30 minutes and 1 hour prior to the scheduled flight departure. In addition, they would allow for a buffer of this magnitude even if they did not have to worry about traffic or parking. The only noticeable difference between the revealed and stated PAT was related to the buffer size of 30 minutes or less. It was observed that the percentage of travelers who state that they would allow for such a buffer is higher than the percentage of travelers who actually allowed for such a buffer.

Specific to the DFW sample, it was found that the item desired by the highest percentage of respondents is information about the delays on specific routes. Furthermore, it was found that the information source consulted and preferred by the largest number of respondents was the Internet. Additionally, it was observed that just over 30% of DFW travelers find the airport to be very congested, while just over 40% think it is only slightly congested. Finally, the majority of DFW air travelers feel that public transportation to the airport is either poor or non existent.

The exploratory results discussed in this chapter provide a basis for the specification of models that address the following aspects of air traveler behavior: PAT at the airport and willingness to adopt new access modes.

Chapter 6.
Stated Preference Models and Their Implications

Introduction

This chapter is divided into three major sections. The first two sections examine two aspects of air travelers' behavior, specifically their preferred arrival time (PAT) at the airport and their willingness to adopt new access modes, respectively. Within the first section, the results of the PAT models estimated for Dallas/Fort Worth (DFW) and Austin are discussed. The second section includes the estimation results for the propensity to use the hypothetical access modes. The third section is intended to illustrate the application of the stated preference models developed in the first two sections of this chapter to the issue of prediction. This is accomplished through the development and comparison of probabilities that air travelers use the three proposed modes as revealed in the three surveys.

Pooled Preferred Arrival Time Model for Dallas/Fort Worth and Austin

In order to compare the revealed and stated PAT for DFW and Austin travelers, one pooled ordered response model was estimated. In performing this estimation, two assumptions were made: there is a constant and identical utility threshold across the combined population and latent variables are independently and identically distributed. Both DFW and Austin data sets were used, resulting in 560 observations (300 + 260). The model was segmented by city as well as by revealed versus stated PAT. The results for this model are presented in Table 6.1.

As noted in Table 6.1, all variables with the exception of the trip-related characteristics are not specific to a city or to the revealed versus stated PAT. The results for the stated and revealed pooled PAT models, which were estimated for DFW and Austin separately, indicated that the revealed and stated PATs are affected by the same factors. Thus, restrictions were imposed on the variables (with the exception of the trip-related variables) to test whether they have the same impact on the revealed and stated PAT, not only for the same city but also for two different cities.

Figures 6.1 and 6.2 present a summary of the relative effects of the different factors on the preflight time buffer allowed by travelers in Austin and DFW. Figure 6.1 shows the relative effects of factors that are binary variables taking a value of 0 or 1; Figure 6.2 shows the relative effect of variables that are categorical. For example, the variable frequent flyer takes the value of 1 if the traveler is a frequent flyer, and 0, if not a frequent flyer. On the other hand, age, education, and number of cars in the household are categorical.

Table 6.1 Pooled PAT model for DFW and Austin travelers

Independent variable	Estimated Coefficient	Standard Error	t-statistic
Constant	1.090	0.447	2.438
Household size	0.128	0.048	2.658
Number of autos in the household	-0.178	0.071	-2.499
Education	0.100	0.060	1.678*
Age	0.099	0.038	2.614
Frequent flyer	-0.170	0.109	-1.556+
Energy conscious traveler	-0.679	0.323	-2.101
Usually travel with a friend	-0.361	0.174	-2.077
Usually travel on business	-0.252	0.110	-2.292
Revealed Preference			
Left from a business location	-0.539	0.240	-2.243
Trip was international	0.474	0.175	2.711
Stated Preference			
Constant	-0.867	0.115	-7.536
Threshold 1	1.846	0.088	20.986
Threshold 2	3.659	0.206	17.778

* Variable significant at the 10% level

\+ Variable significant at the 20% level

Auxiliary Statistics	At convergence	Initial
Log likelihood	-506.99	-566.44
Number of observations	560	

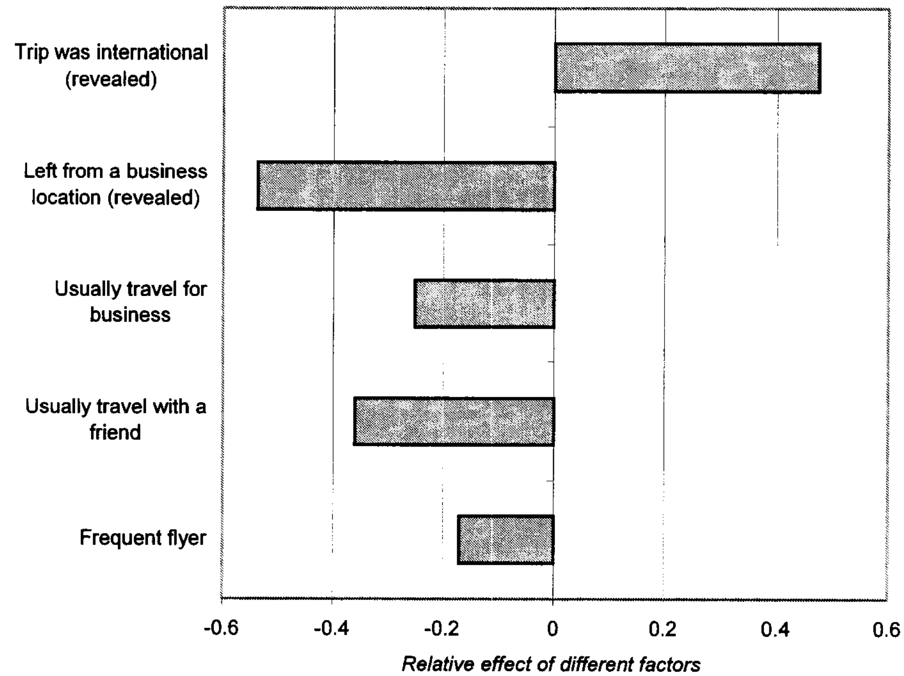


Figure 6.1 Comparison of the relative effects of different binary variables on the earliness buffer

From Figure 6.1, we note that leaving from a business location has an approximately equal and opposite impact on the revealed PAT as the trip destination. Business travelers and frequent flyers favor smaller buffers. However, whether the individual is a business traveler or a frequent flyer, the effect on the PAT is practically the same. This is expected because frequent flyers are typically business travelers and vice versa. It is interesting to note that individuals who usually travel with a friend favor smaller buffers than frequent or business travelers.

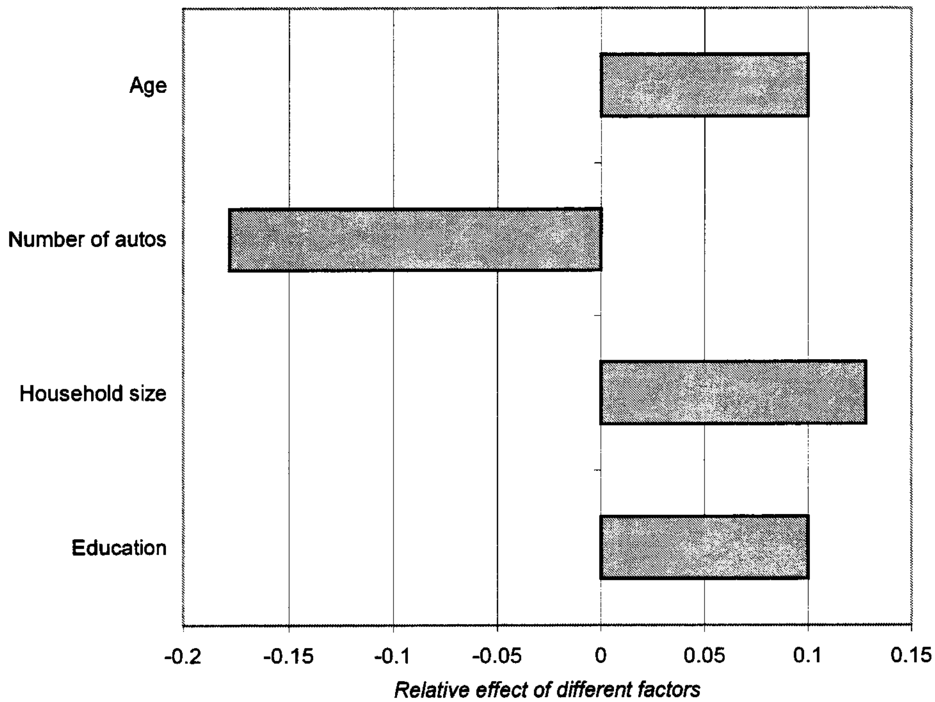


Figure 6.2 Comparison of the relative effects of different categorical factors on the earliness buffer

Of the variables included in Figure 6.2, only the number of autos has a negative impact on the buffer. The household size and the level of education have the same positive impact on the buffer.

Models for the Propensity to Use Access Modes

This section presents the parameter estimation results of the stated preference models for the new airport access modes specified in Section 5.2, for DFW, Austin, and Houston, using the survey data described in Chapter 5. This set of models pertains to respondents' stated intentions in response to new transit, rail, and off-airport terminals as analyzed using ordered probit models designed to measure the underlying propensity to use these services. Concluding this section are the results for a pooled model where the data from all three surveys were used to estimate one single model.

Propensity To Use Access Modes in Dallas/Fort Worth

The survey included three different services (transit, rail, and off-airport terminals) and each one had four variants. Each individual was asked to indicate his or her willingness to adopt each of those services, and the responses were measured along a four-point scale. Stated responses for the different variants of a given service were treated as a single dependent variable. Individual responses for each variant of any given service were treated as independent observations. For example, each of the three services (transit, rail, and off-airport terminals) had four variants, and thus four independent observations were replicated for each individual explanatory variable (Ref 42). However, these choices may not be independent because of autocorrelation among observations on the same individual, though these effects are ignored in this project (Ref 42).

Rather than estimating three separate models for each of the services, a single model that incorporates all three services was specified and estimated. The benefit of a single model is twofold: (1) it reduces the number of specifications to be reported and (2) the number of observations in the estimation data set increases, improving the statistical properties of the estimators. Instead of 600 observations for each model (150 observations x 4 variants), we had 1,800 observations (150 observations x 4 variants x 3 services).

Table 6.2 presents the estimation results for the model of propensity to use the new services. All of the variables intended to capture respondents' willingness to adopt these services are statistically significant at the 5% level. The model is segmented along three dimensions: mode, gender, and frequent flyer status.

As seen in Table 6.2, the factors that impact respondents' willingness to adopt each of the three services are not the same. Moreover, the gender of the traveler and whether that traveler is a frequent flyer or not influence the willingness to use each of the three services in different ways. The results for this model are discussed in sequence: first, the factors that interact with the transit mode; followed by rail usage; and, finally, off-airport terminals.

The age of the traveler affects the willingness to adopt transit as a means to reach the airport. Older non frequent travelers are more likely to use the service. One reason might be that older travelers prefer avoid with the hassles of congestion and parking. Age does not have an influence on frequent flyers because such travelers are comfortable with air travel and thus the effect of age diminishes.

Table 6.2 Model for the propensity to use new services from DFW's stated intentions data

Independent variable	Estimated Coefficient	Standard Error	t-statistic
Constant	0.634	0.472	1.344
Transit			
Perceived level of transit in the area	-0.069	0.035	-1.977
Education	-0.127	0.063	-2.001
Energy conscious traveler	0.783	0.242	3.230
Non-frequent Flyers			
Age	0.235	0.033	7.061
Males			
Usually travel on business	-0.460	0.114	-4.026
Traveler is sociable	1.726	0.411	4.192
Frequent Flyers			
Number of autos in the household	0.253	0.075	3.370
Females			
Traveler is sociable	1.175	0.474	2.478
Rail			
Constant	0.747	0.620	1.204
Perceived level of congestion	0.122	0.053	2.319
The traveler is a licensed driver	-0.964	0.338	-2.854
Traveler is sociable	3.028	0.400	7.565
Non-Frequent Flyers			
Household size	-0.261	0.051	-5.194
Frequent Flyers			
Traveler has a need for independence and control	-1.626	0.355	-4.576
Females			
Frequent Flyer	-0.439	0.124	-3.542
Usually travel with a friend	1.018	0.302	3.371
Off-Airport Terminals			
Constant	-0.286	0.473	-0.605
Frequent Flyer			
Whether the traveler is a non resident	0.319	0.111	2.877
Threshold 1	0.819	0.035	23.105
Threshold 2	2.097	0.051	41.455

Auxiliary Statistics	At convergence	Initial
Log likelihood	-2147.9	-2416.1
Number of observations	1800	

The more educated the individual is, the less likely he or she is to use transit. Male travelers who usually travel for business are less likely to use the transit service. This might be because business travelers typically are reimbursed travel costs and thus have the option of using more expensive modes without having to worry about the cost (e.g., taxi). The trip purpose is only significant for males, though the sample may be inadequate to distinguish such an effect for female travelers (80% of the business travelers in the sample are male).

Travelers who are energy conscious are more likely to use the transit service, as are those who are sociable. This effect appears more pronounced for males than for females. Travelers were asked to rate public transportation between their home and the airport. The model parameter estimates indicate that if travelers do not perceive transit as being very reliable, they are less likely to use the new service.

As the number of cars increases in the sample households, frequent flyers are more likely to use the transit service. This is expected because the suggested locations of the transit terminals were a 15-minute drive from the respondent's place of residence. Thus, the possibility of a drop-off at the terminals increases if more cars are available in the household. That would be more appealing than dropping off the passenger at the airport because of the longer drive. This variable was not significant for non frequent flyers because it would not be a hassle to drop off such passengers at the airport rather than at the transit terminals given the fact that they travel once or twice per year.

For the rail access mode, respondents with negative perceptions of congestion were more likely to use rail, which would have a separate right-of-way and thus would not be affected by highway congestion. Nevertheless, licensed drivers are less likely to use the rail service.

Non frequent flyers from larger households appear to be less likely to use rail, presumably because of a larger pool of possible rides to the airport. Travelers who are sociable are more likely to use the service, while female frequent flyers are less likely to use the service, possibly because of safety perceptions. Concern over safety is further suggested by the finding that if a female usually travels with a friend, she would be more likely to use the service. Finally, frequent flyers who have a need for independence and control are less likely to use rail service. Such travelers value using their private cars and are less willing to use other means of transportation.

The third set of variables interacted with the use of off-airport terminals as an alternative for airport access. At such terminals, passengers would have the option of checking their luggage and obtaining their boarding passes. They would then be transported to the airport by vans that carry up to fifteen passengers. Only one factor had an impact on travelers' propensity to use the service. Non resident frequent flyers are more likely to use the service. This might be because the suggested locations of the terminals were in the downtown area where non resident frequent flyers typically attend to most of their business. Thus, it might be convenient for them to use the service rather than renting a car to drive to the airport.

The previous discussion focused on the factors that affect each of the three modes separately. In addition, several factors had an impact on more than one mode. Travelers who are sociable (both males and females) are more likely to use transit or rail. Moreover, sociable males are more likely to use transit than females. On the other hand, rail usage is not influenced by the gender of the sociable individual.

Propensity To Use Access Modes in Austin

Table 6.3 presents the estimation results for the propensity to use the hypothetical new services using data from the Austin survey. An approach similar to the one adopted for the DFW model was used. Most of the variables intended to capture respondents' willingness to adopt these services are statistically significant at the 5% level, as seen in Table 6.3. The households yearly income and the variable on energy conscious males for the off-airport service are significant at the 10% level. The coefficients for non residents for transit, and business frequent flyers and energy conscious females for off-airport service, are significant at the 20% level. These variables were retained in the model for comparison purposes and because of their intuitive meaning. The model is segmented along three dimensions: mode, gender, and frequent flyer status.

As noted in Table 6.3, the variables that have an impact on the propensity to use the new services are somewhat different from those that were retained in the DFW model. This may be attributed to the scale difference between the two cities.

The results for this model indicate that only two variables have a negative impact on the propensity to use transit: being a non resident and having the need for control and independence.

Unlike more educated travelers in DFW, similar travelers in Austin are more likely to use transit. On the other hand, in DFW and Austin, energy conscious travelers and females who have more cars in their household, , are more likely to use the service.

Most variables for the rail mode, except four, have a negative impact on the propensity to use rail. The four variables that favor the use of rail are female business travelers, energy conscious females, the yearly household income for females, and the perceived transit level for frequent flyers.

Table 6.3 Model for the propensity to use new services from Austin's stated intentions data

Independent variable	Estimated Coefficient	Standard Error	t-statistic
Constant	-1.244	0.471	-2.642
Transit			
Whether the traveler is a non resident	-0.249	0.166	-1.497+
Usually traveler with a member of the household	0.394	0.111	3.544
Energy conscious traveler	2.454	0.403	6.093
Traveler has a need for independence and control	-1.245	0.457	-2.723
Males			
Education	0.303	0.065	4.641
Females			
Education	0.180	0.064	2.806
Number of autos in the household	0.269	0.085	3.159
Frequent Flyers			
Usually travel on business	0.366	0.162	2.259
Rail			
Constant	5.130	0.610	8.413
Males			
Energy conscious traveler	-2.013	0.437	-4.605
Traveler has a need for independence and control	-4.600	0.547	8.411
Females			
Perceived level of transit in the area	-0.300	0.056	-5.312
The traveler is a licensed driver	-1.632	0.343	-4.765
Household yearly income	0.70E-05	0.22E-05	3.127
Usually travel on business	0.594	0.189	3.149
Energy conscious traveler	1.072	0.425	2.525
Traveler has a need for independence and control	-2.449	0.605	-4.049
Frequent Flyers			
Perceived level of transit in the area	0.282	0.036	7.932
Female traveler	-0.451	0.180	-2.518
Household yearly income	-0.90E-05	0.12E-05	-7.542
Off-Airport Terminals			
Constant	2.278	0.585	3.891
Household yearly income	-0.17E-05	0.11E-05	-1.646*
Males			
Energy conscious traveler	-0.832	0.473	-1.760*
Females			
Energy conscious traveler	0.613	0.393	1.558+
Traveler has a need for independence and control	-2.386	0.548	-4.349
Frequent Flyers			
Usually travel on business	-0.180	0.142	-1.262+
Threshold 1	0.978	0.042	23.345
Threshold 2	2.148	0.054	39.425

* Variable significant at the 10% level

\+ Variable significant at the 20% level

Auxiliary Statistics	At convergence	Initial
Log likelihood	-1836.86	-2122.03
Number of observations	1560	

Comparing the variables that had an impact on the propensity to use rail in DFW and Austin, we observe that individuals who have a need for control and independence, female frequent flyers, and females who are licensed to drive are less likely to use rail in both cities. The rest of the variables that had an impact on the propensity to use rail in Austin were not retained in the DFW model.

The third set of variables affect the use of off-airport terminals in Austin. All three variables retained in the model have a negative impact on the propensity to use off-airport terminals.

Several variables were found to have an influence on the propensity of travelers to adopt at least two of the three modes. For example, it was observed that energy conscious female travelers are likely to use any of the three modes. Males, on the other hand, are more likely to use transit as opposed to using rail or off-airport terminals, if they are energy conscious. Travelers who have a need for control and independence, whether they are male or female are less likely to use any of the three services. Finally, business travelers favor transit over off-airport terminals.

Propensity To Use Access Modes in Houston

Table 6.4 presents the estimation results for the propensity to use the new services using data from the Houston survey. All but three variables are significant at the 5% level. The energy conscious frequent flyer status and usually traveling with a friend for transit and the perceptions of congestion level for off-airport terminals are significant at the 10% level. The model is segmented along three dimensions: mode, gender, and frequent flyer status.

As observed in Table 6.4, all variables have a positive impact on the propensity to use transit, which was not the case for either DFW or for Austin. However, there are some similarities between this model and the previous two. For example, energy conscious travelers are more likely to use transit in Houston and the same was observed for DFW and Austin. Moreover, and similar to the DFW model, older travelers and sociable males are more likely to use the service.

For rail, as opposed to transit, most variables have a negative impact on the propensity to use the service. One variable increases the propensity to use rail: number of licensed drivers in the frequent flyer's household. Similar to what was observed for DFW and Austin, female frequent flyers are less likely to use rail. On the other hand, negative perceptions of transit reduce frequent flyers' propensity to use rail while the opposite was observed for Austin.

Table 6.4 Model for the propensity to use new services from Houston's stated intentions data

Independent variable	Estimated Coefficient	Standard Error	t-statistic
Constant	-4.697	0.961	-4.889
Transit			
Age	0.557	0.089	6.233
Usually travel with a friend	0.837	0.470	1.781*
Non Frequent Flyers			
Energy conscious traveler	3.134	0.921	3.403
Males			
Traveler is sociable	3.554	1.067	3.332
Frequent Flyers			
Perceived level of transit in the area	0.190	0.096	1.975
Energy conscious traveler	1.400	0.780	1.794*
Females			
Energy conscious traveler	4.538	1.150	3.945
Rail			
Constant	7.644	1.030	7.420
Age	-0.196	0.066	-2.959
Frequent Flyers			
Perceived level of transit in the area	-0.510	0.062	-8.238
Female traveler	-1.148	0.268	-4.289
Household size	-1.190	0.166	-7.166
Number of licensed drivers in the household	2.597	0.314	8.262
Off-Airport Terminals			
Constant	5.153	0.974	5.292
Whether the traveler is a non resident	0.549	0.216	2.539
Frequent Flyers			
Perceived level of congestion	0.261	0.135	1.930*
Perceived level of transit in the area	-0.363	0.082	-4.421
Household size	-0.684	0.152	-4.508
Number of licensed drivers in the household	1.208	0.273	4.428
Threshold 1	0.984	0.079	12.473
Threshold 2	2.360	0.111	21.338

* Variable significant at the 10% level

Auxiliary Statistics	At convergence	Initial
Log likelihood	-617.1	-800.6
Number of observations	588	

The use of off-airport terminals is influenced by five variables with two having a negative impact on the propensity to use the service: perceptions of transit service level and household size for frequent flyers. It was observed that non residents are more likely to use off-airport terminals and this same phenomenon was observed for DFW.

Finally, the impact of several variables that were found to have an influence on the propensity of travelers to adopt at least two of the three modes is discussed. It was observed that the age of the traveler has a negative impact on using rail while favoring transit usage. A negative perception of transit for frequent flyers is likely to reduce their propensity to use rail or off-airport terminals while increasing their propensity to use transit, which negates what we would have expected. Larger household sizes have a negative impact on the propensity to use rail or off-airport terminals for frequent flyers. Finally, frequent flyers are more likely to use rail or off-airport terminals if several members of their household are licensed drivers. It should be noted, however, that the propensity to use transit was not influenced by the previous two factors.

Pooled Model for the Propensity To Use Access Modes

The previous three sections dealt with the results for models estimated using data from three different surveys. The results gave some insight into the factors that affect respondents' willingness to adopt the hypothetical new services. The results were compared across modes for a given city. However, the structure of the models did not allow comparison of the results across cities and modes at the same time. Thus, a model was estimated using the data obtained from all three surveys and was segmented by city (DFW, Austin, and Houston) and mode (transit, rail, and off-airport terminals).

The number of observations is 3,948, which is the sum of the number of observations for all three surveys (1,800 + 1,560 + 588). The preferred specification of this model includes 48 significant variables. Thus, only interesting comparisons between factors that had an influence on the propensity to adopt different modes for different cities are presented. Table 6.5 presents the impact of key variables that were found to have an influence on the propensity of travelers to adopt at least two of the three modes across the three different cities.

From Table 6.5, we note that age has the same positive impact on the propensity to use the three hypothetical new modes in DFW. In Houston, age has a positive impact on transit but a negative impact on rail.

The restriction that business travelers are unlikely to use all three modes in DFW was valid. On the other hand, business travelers in Austin are equally likely to use transit or rail but less likely to use off-airport terminals.

Table 6.5 Factor impact across modes from the pooled model

	DFW	AUS	HOU
Age			
Transit	0.08 (4.98)		0.52 (6.56)
Rail	0.08 (4.98)		-0.22 (-2.43)
Off-airport	0.08 (4.98)		
Usually travel for business			
Transit	-0.24 (-4.12)	0.46 (5.19)	
Rail	-0.24 (-4.12)	0.46 (5.19)	
Off-airport	-0.24 (-4.12)	-0.27 (-1.97)	
Traveler is sociable			
Transit	1.32 (5.57)		1.32 (5.57)
Rail			3.37 (5.52)
Off-airport	1.32 (5.57)		1.32 (5.57)
Non residents			
Transit		-0.34 (-3.61)	
Rail		-0.34 (-3.61)	-1.00 (-4.44)
Off-airport	0.43 (4.98)	-0.34 (-3.61)	0.43 (4.98)
Education			
Transit	-0.11 (-2.83)	0.14 (4.25)	
Rail	-0.11 (-2.83)	0.14 (4.25)	
Off-airport	-0.11 (-2.83)	0.14 (4.25)	
Energy conscious traveler			
Transit	0.75 (5.39)	2.29 (6.08)	2.09 (4.88)
Rail	0.75 (5.39)		2.09 (4.88)
Off-airport	0.75 (5.39)		2.09 (4.88)
Need for control			
Transit	-0.67 (-2.43)	-1.13 (-2.50)	
Rail	-0.67 (-2.43)	-3.35 (-8.72)	
Off-airport	-0.67 (-2.43)	-2.24 (-4.69)	
Frequent flyer			
Transit	-0.59 (-5.97)		
Rail			-0.52 (-2.77)
Off-airport	-0.18 (-1.88)		

Note: Numbers in parentheses are t-statistics.

Auxiliary Statistics	At convergence	Initial
Log likelihood	-4633.09	-5345.38
Number of observations	3948	

A restriction was imposed on the effect of being sociable in DFW and Houston. The results from the model indicate that being sociable has the same positive impact on the propensity to use transit or off-airport terminals in both cities. Another restriction that was imposed on travelers from two different cities pertains to non residents. It was observed that being a non resident has the same positive impact on the propensity to use off-airport terminals in DFW and Houston. On the other hand, being a non resident has the same negative impact on the propensity to use all three modes in Austin.

The impact of education was restricted to be the same across all services for DFW. A similar restriction was imposed for Austin travelers. It was observed that the level of education has an equal and negative impact on the willingness of DFW travelers to use the new modes, while having an equal and positive impact in Austin.

Energy conscious travelers are more likely to use the new access modes in DFW, Austin, and Houston. However, the impact of this variable was restricted to be the same for DFW travelers and similarly for Houston travelers.

Finally, travelers who have a need for control and independence are less likely to use the services in DFW and Austin.

Implications of the Stated Preference Models

The previous two sections presented the estimation of the stated preference models for the new airport access modes for DFW, Austin, and Houston, which were based on the ordered-response theory. These models provide a systematic and quantitative analysis of the adoption process of new airport access modes by air travelers, which yields insight into the underlying behavioral process. The relative importance of the factors that influence these choices has implications for the design of such services, the role that they might play as a demand management tool, and policy actions that might encourage provision of such services.

An important motivation of the quantitative analysis is to predict the extent to which the three access mode services might be adopted under given circumstances. Public transportation tailored for the specific needs of air travelers has been advocated as a promising substitute for private vehicle travel to airports - the major cause of traffic congestion and air pollution during peak hours along airport access facilities. The level to which public transportation is adopted determines the potential impact of such services on the airport access system. Furthermore, this matter is of concern to airport planners and metropolitan planning organizations.

Figure 6.3 presents the predicted probabilities of probably or definitely using the three modes in DFW, Austin, and Houston. From Figure 6.3, we note that the percentage of individuals who will probably or definitely use any of the services in DFW and Houston are similar, whereas those percentages are much lower for Austin. The percentage of individuals who will probably or definitely use transit in DFW and Houston are 88% and 91%, respectively, while that figure drops to 51% in Austin. The percentages for rail are slightly higher for Houston (67%) than for DFW (56%). For both DFW and Houston, the percentages drop from transit to rail, and they also drop from rail to off-airport terminals. On the other hand, in Austin the percentage of individuals who will probably or definitely use rail (23%) is similar to the percentage of individuals who will probably or definitely use off-airport terminals (19%).

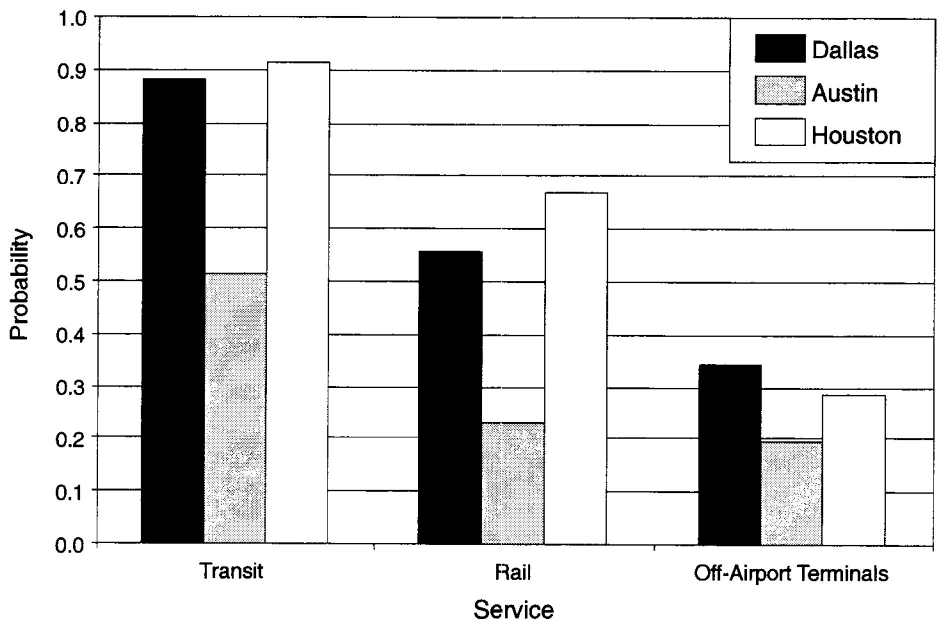


Figure 6.3 Predicted probabilities for probable or definite use of the services in the three cities.

The predicted probabilities for frequent flyers from the three cities were also compared. Figure 6.4 presents the predicted probabilities of probably or definitely using the three modes for frequent flyers in DFW, Austin, and Houston.

Again, frequent flyers' behavior in Houston and DFW is similar, though it differs from the behavior of frequent flyers in Austin.

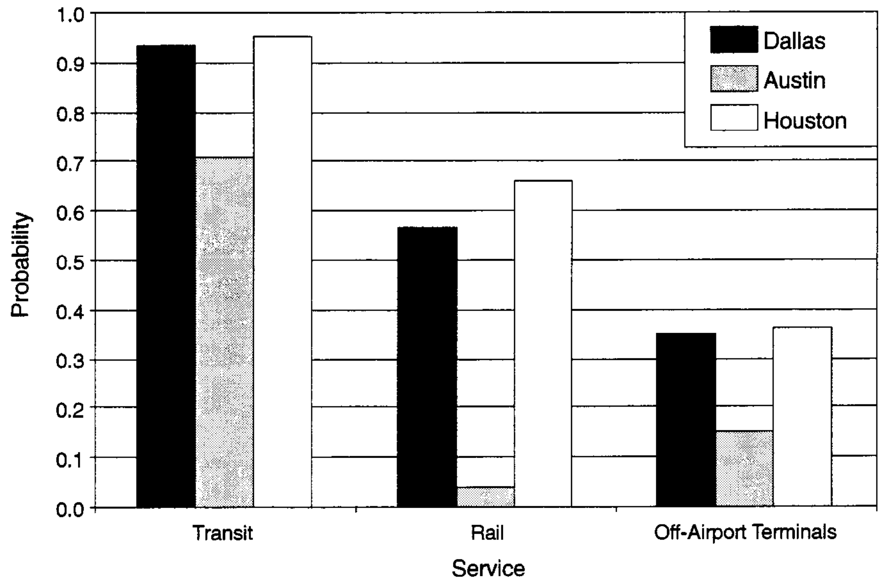


Figure 6.4 Predicted probabilities for probable or definite use of the services for frequent flyers in the three cities

Finally, the predicted probabilities for mode usage were compared across the three cities for females only. Figure 6.5 presents the predicted probabilities for females of probably or definitely using the three modes in DFW, Austin, and Houston.

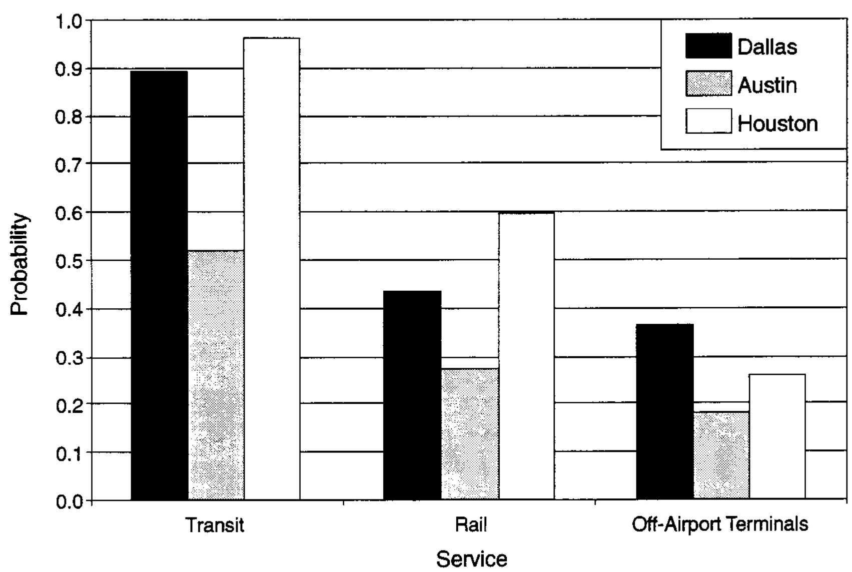


Figure 6.5 Predicted probabilities for probable or definite use of the services for females in the three cities

This figure illustrates that females, as opposed to males, are much more likely to use transit. For this segment, the predicted probabilities in Austin are more comparable to those in DFW or Houston. However, for females the striking difference between the cities lies in rail usage. It is predicted that 4% of females will probably or definitely use rail in Austin, while that value increases to 56% in DFW and 66% in Houston. Perhaps Austin respondents factor in the lower likelihood that rail might become available compared to the much larger DFW metroplex.

Summary

This chapter examined two aspects of air travelers' behavior, specifically PAT at the airport and their willingness to adopt new access modes. It presented an analysis of travelers' PAT and the main differences between various traveler segments, such as males, females, frequent flyers, and non residents. Moreover, travelers' willingness to adopt different airport access modes was analyzed along the same lines.

The estimated PAT models for DFW and Austin confirmed most of the exploratory findings presented in Chapter 5, namely, passengers' PAT is influenced by: (1) trip duration, (2) age, (3) education level, (4) household size, (5) yearly household income, and (6) the three attitudinal factors identified from the factor analysis.

The results for the models estimated for the stated responses to the hypothetical new services indicated that older, sociable, and energy conscious travelers are more likely to use the services. On the other hand, business travelers and those who have a need for control and independence are less likely to use the hypothetical new services. The implications of these estimated stated preference models for the likely adoption of new access services were also discussed in this chapter.

Specifically, predictions of the mode usage by residents of DFW, Austin, and Houston were presented. In addition, separate predictions for frequent flyers and females were presented and compared. The prediction results indicate that transit would be used by the highest percentage of individuals in all three cities (among the new access transport services). In fact, definite transit usage varies from about 20% in Austin to 74% in Houston. For rail, the highest percentage of users will be in Houston where it is predicted that about 28% of the respondents will definitely use that mode for their trip to the airport. These numbers may well reflect the respondents' assessment of the likely availability of the various options.

Chapter 7.
Analysis of Airport Accessibility at the Network Level

Introduction

As stated in Chapter 1, a primary objective of this research is to develop a methodology for the evaluation of short, medium, and long-term solution strategies for the alleviation of airport access congestion. The primary tool used for this research is DYNASMART-IP, a dynamic network analysis tool developed at The University of Texas at Austin, UT and adapted for the specific purpose of this project. DYNASMART-IP was selected because of its ability to model intermodal access on a network—necessary for modeling direct rail service from off-airport locations, as described in Chapter 4. Using the Dallas/Fort Worth DFW) metroplex as an example, the following two sections provide a step-by-step process for developing a test network area as well as the inputs and model descriptions needed to simulate airport access scenarios using DYNASMART-IP. Finally, the third section presents the scenarios that were simulated as well as the results and conclusions of the analysis.

Designing the Test Network

The link, node, and zone details are needed as inputs in the DYNASMART-IP model. A 1995 TransCAD network file of the DFW area included a link, node, and zone database. The link database included the following information on all of the 21,000 links in the network: length, number of lanes, signal control type at each upstream and downstream node, lane type (i.e., arterial, highway, high-occupancy vehicle (HOV), etc.), maximum speed, and street name. The node database included the longitude and latitude for the 6,000 nodes in the network. The zone information included the area of the 919 zones and the longitude and latitude of each zone. Before the data could be modeled for the network, it was necessary to reduce the size of the network to a more realistic test area that accurately represents the potential problem and improvement areas for the Dallas/Fort Worth International Airport (DFW Airport). Therefore, the next step is determining which links were needed for the test network. The test network did not need to be as detailed as the original network, which included all streets, highways, and zones in the entire network. The original TransCAD file included 919 zones, over 21,000 links, and approximately 6,000 nodes.

The following criteria were used to evaluate and screen links to determine if they would be included in the condensed test network. The links that met any one of these criteria were included in the test network.

Link Evaluation Criteria

- State highway leading to either downtown Dallas or Fort Worth from DFW Airport
- Interstate highway leading to downtown Dallas or Fort Worth from DFW Airport
- Local street leading into DFW Airport

The evaluation criteria allow the links surrounding the DFW Airport, as well as the main highways leading into DFW Airport from downtown Dallas and Fort Worth, to be evaluated rather closely for improvement strategies.

The downtown areas of Dallas and Fort Worth were given extra emphasis as well because both downtowns are high attraction areas to DFW Airport and potential locations for the off-airport terminals that are tested as part of the improvement strategies. DYNASMART-IP models direct rail from both of these downtown off-airport terminal locations.

The local streets surrounding DFW were included in the network representation to investigate any potential bottlenecks on the main streets leading into the airport. Potential short-term and long-term improvements to the local streets can be suggested, as well as evaluating the effects of incidents and variable message signs, displaying airport-related information, on the network.

Once the evaluation criteria were set, the links were identified as either test network links or links that could be deleted with no direct impact on the analysis results. The next step was to delete those links in TransCAD. Following is a step-by-step process to deleting links using TransCAD software.

1. Choose **Tools-Map Editing**
2. Activate the Delete tool by clicking on it.
3. Click the lines you want to delete one by one. TransCAD marks each deleted line in red.
4. Click Green Light to save the edit, or the Red Light to cancel (Ref 48).

After all the identified links were deleted, the test network was composed of the remaining 1,532 links. Another modeling consideration was to ensure the directions of the links accurately represented the directions of the streets in the network. Therefore, it was necessary to make the links that were two-way streets accurately represented in TransCAD. The process of *dualizing* the links allows the user to make links bi-directional. The next phase in designing the test network was combining the 919 zones into twelve larger *superzones*.

Selecting the Zones and Nodes

The original network file included 919 zones, which represented all the zones in the DFW area. The test network was condensed to 1,532 links that included the main local streets around the airport and the main highways leading out of the airport. Therefore, it was not necessary to keep the original set of zones because many of the original zones did not have any links included after the test network was constructed and could be combined with neighboring zones for a better-focused analysis on airport-related issues. The 919 zones were combined into twelve main zones. Adjacent nodes were combined with the highways serving as boundaries for most zones. The new zones reflect the attributes of the original zones, such as area, longitude, and latitude. The twelve zones include separate zones for the DFW Airport, downtown Dallas, and downtown Fort Worth. The following is a description of how zones are combined in TransCAD:

1. Choose **Tools-Map Editing.**
2. Activate the Join tool by clicking on it.
3. Click on the first area you want to join. TransCAD displays editing handles on the boundary.
4. Click on one or more areas that you want to join with the first one. TransCAD displays editing handles on the boundary and marks in red any boundary line that separates the areas to be joined.
5. Click the Green Light to save the edits or click the Red Light to cancel (Ref 48).

Similarly, the nodes in the test network were selected according to the links that are in the test network. The nodes selected correspond to the endpoints of the links in the network. These nodes were evaluated to identify potential high-demand intersections or bottlenecks that affect the network.

The new test network includes twelve superzones, 1,532 links, and 655 corresponding nodes. Figure 7.1 is a diagram of the test network. The next section details the development of the time-dependent origin-destination matrix—one of the key inputs into the DYNASMART-IP model.

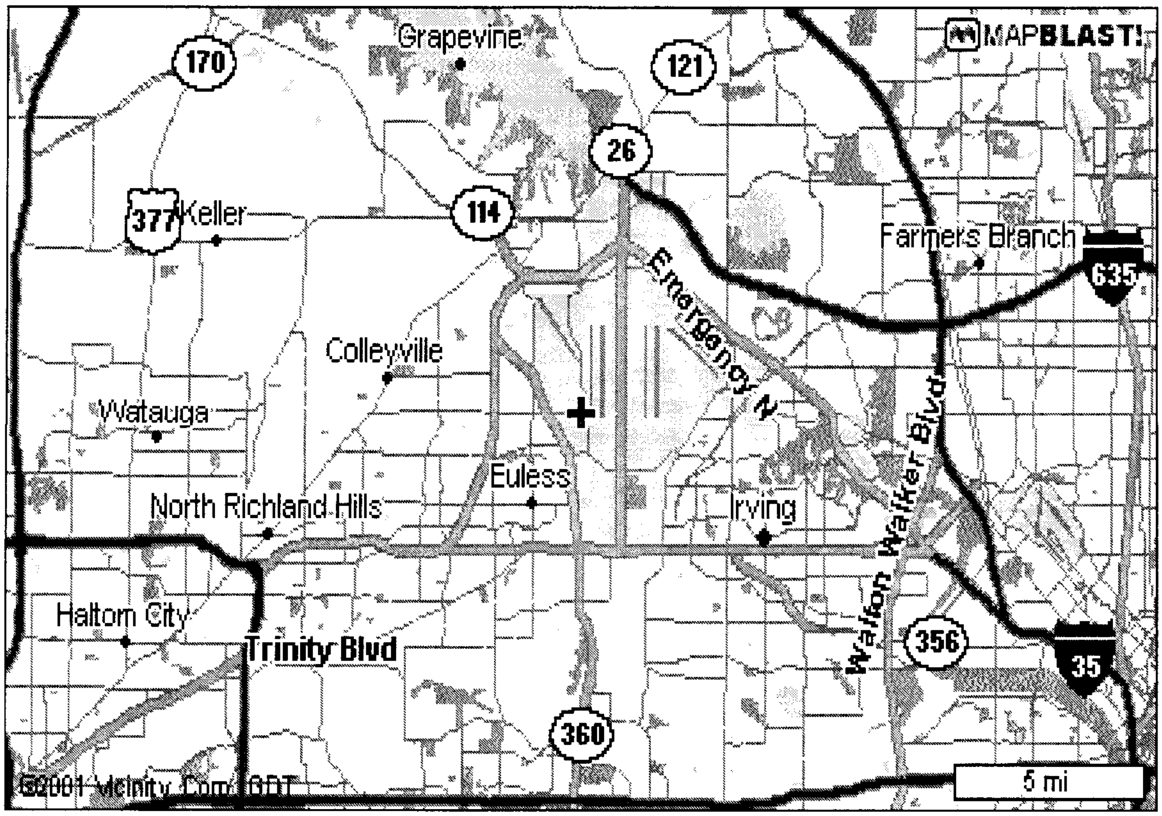


Figure 7.1 Test network for DYNASMART-IP

DYNASMART-IP Inputs

DYNASMART-IP can represent the elements of the test network, such as zone, intersections, links, origins, and destinations, with varying degrees of detail or coarseness depending on the purpose of the analysis. In airport access applications, one would expect greater detail in the vicinity of the airport and major arteries leading to it from the major generators, as well as around facilities directly involved in air travel, such as off-airport terminals. These principles have guided the development of the test network and the specification of its different elements, especially the zonal configuration and associated origin-destination demand inputs. The zonal configuration in the test network, along with the origins and destinations that belong to each zone, were specified for the DFW application. As noted previously, the origin/destination (O/D) matrix was developed from a 1995 passenger survey of workers in the DFW area. Types such as freeways, ramps, arterials, HOV toll lanes, etc. represent links. Each link is characterized by its length, number of lanes, existence of left-turn bays, maximum traffic speeds, etc. This link information is included in the 1995 TransCAD network file for the test network. Link junctions with different signalized and nonsignalized control options are also modeled in DYNASMART-IP. Finally, DYNASMART-IP represents trip origins, destinations and intermediate destinations in case of trip chaining. This origin and destination information was obtained through a 1995 passenger survey of workers in the DFW area.

The methodology for preparing the inputs necessary for the generation of vehicles onto the network includes specification of OD matrices among OD zones at different demand intervals A flexible dynamic demand input format is used in DYNASMART-IP. The number of loading intervals, a multiplication factor for demand generation, starting time of each period, and the end of vehicle generation time are defined. DYNASMART-IP models any common control at the link junctions such as no control, yield signs, stop sign, pretimed signals, and actuated signals. At the signalized intersections, the phasing pattern, movements, and other signal settings to represent any real network are specified. The signal control information for the test network was obtained through the TransCAD network file as well as signal control information provided by the Texas Department of Transportation (TxDOT).

The model also represents background traffic, i.e., vehicles with predetermined routes, such as transit and other service-type vehicles. The transit operation requires, at a minimum, the representation of rail lanes, start times, stop locations, and dwell times.

Network Data File

The network data file contains the overall description of the network, such as the number of zones, number of nodes and links, upstream and downstream nodes, and centroid of each zone.

The following is the general format of the network file (network.dat) for the test network.

```
12  655 1532   12    2 1200 2000   12
1   11    0
2   11    0
... ...
13    3    1
... ...
1    2    0    264 0 2 1.000 0.611 1
1    5    0    422 0 2 1.000 0.611 1
```

The above data represents a twelve-zone test network consisting of 655 nodes and 1,532 links. Node 13 is a generation node. Node 1 connects to nodes 2 and 5. Link 1 starts at node 1 (upstream node) and ends at node 2 (downstream node), has no left-turn bay, and is 264 feet long. The link consists of two lanes with a maximum speed of 1.000 miles per minute (60 mph). The maximum flow rate is .611 vehicles per second (2,200 vehicles/hr).

Developing the Time-Dependent Origin Destination Demand Loading Pattern

For each time period, an OD matrix (zone-to-zone) needs to be prepared in order to generate and load vehicles onto the network. The demand-loading component determines the number of travelers to be generated every simulation interval. Each generated traveler is assigned a set of attributes, which include his or her trip-starting time, generation link, final destination, and a distinct identification number. This allows the user to specify any demand level and demand distribution between zones, along with any temporal loading pattern.

The OD input pattern for the test network was developed in the following manner. Results from a 1995 North Central Texas Council of Government (NCTCOG) passenger survey were used to develop the OD static matrix. The household work trip survey contained the following information: trip origin zone and trip destination zone. These zones aligned with the 919 origin zones from the original network.

Table 1
Static Demand File

		Zone												Total
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
Zone	**1**	16	2	0	4	0	30	3	5	31	1	6	37	135
	2	4	132	11	24	0	30	29	5	7	11	53	50	356
	3	0	12	32	41	0	0	57	1	5	12	44	20	224
	4	0	1	22	489	17	0	118	3	6	27	20	25	728
	5	2	0	4	21	82	3	30	9	3	47	8	40	249
	6	54	11	4	7	2	195	13	5	58	14	51	169	583
	7	4	14	25	91	10	6	199	5	3	78	51	60	546
	8	2	1	0	0	10	13	2	76	19	32	17	99	271
	9	18	0	2	2	6	37	13	25	148	12	21	170	454
	10	0	0	2	0	1	3	13	10	2	49	8	43	131
	11	0	5	4	5	0	8	25	6	6	13	69	38	179
	12	5	5	6	6	6	48	14	28	61	44	57	425	705
Total		105	183	112	690	134	373	516	178	349	340	405	1176	4561

In order to develop the OD matrix for the twelve superzones in the test network, it was necessary to first convert the 919 origin and destination zones from the survey into the new twelve zones using SPSS. Once the zone information was converted to the new superzones an OD matrix could be developed between each of the twelve trips. Table 1 shows the static OD matrix of household work-related trips in the DFW condensed test network.

However, a principal requirement of DYNASMART-IP is a time-dependent OD-loading pattern. So it was necessary to determine a demand distribution that would be representative for the test network. The demand distribution pattern was assumed to be the average demand for the first three simulation intervals, followed by a 50% increase for the next two simulation periods, and back to the average demand for the last two simulation periods. This time-dependent demand pattern is the data necessary for the demand input file in DYNASMART-IP.

The demand generated using the household work-related trip survey included approximately 4,500 individual trips, which is very low compared to the actual demand on the network. Therefore, it is necessary to specify a multiplication factor in the demand file so that traffic simulated is a better representation of the network demand. The multiplication factor specified is five because actual demand is about five times more than the survey data results. This type of adjustment is part of the calibration process of the network model when the latter is only a subset of the region's complete network and when the input data is based on existing secondary sources that were not collected specifically for this application. Nonetheless, this aggregate level of calibration produces realistic flow patterns in the network for the purpose of relative assessment of alternative measures.

With the time-dependent OD pattern developed, the next step is entering the demand information and other functions into the model. The following is a sample of the demand (demand.dat) file.

```
7   5
0.0   5.0  10.0  15.0  20.0  25.0  30.0  35.0
0.0000   0.1667   0.0000   0.3333   0.0000   2.5000
0.2500   0.4167   2.5833   0.0833   0.5000   3.0833
```

There are 7 loading intervals, with a multiplication factor of 5. Each loading interval is defined as 5 minutes, as indicated in the list of the starting times of the loading intervals in the above example. The total loading time with 7 loading intervals is 35 minutes. A twelve-zone network with 7 loading intervals requires seven 12 x 12 matrices. Each matrix contains the total number of vehicles per multiplication factor for the respective loading interval. The above data set shows the demand from zone 1 to all other zones in loading interval 1. For example, the demand between zones 1 and 2 in loading interval 1 is .1667x5 vehicles (the 5 is the multiplication factor).

Signal Control Data

The control.dat file specifies the type and parameters of the control at each intersection. The following shows the format for the control.dat file for the test network.

```
1
 0.00
 1 1 0   0
```

In the above example, there is one signal timing plan, starting at time 0.00 (beginning of simulation). There is no signal at node 1.

Movement Data

The movement data file specifies the turning movements for every link according to the network configuration. Each line of the file represents the data for one link (i.e. link 1 is represented on the first line, link 2 on the second line and so on).

The following data shows the general format for the movement.dat file.

1	2	549	0	0	10	0
1	5	0	0	0	0	0
2	10	0	4	0	0	0
2	549	0	7	553	0	0
3	11	554	0	0	0	0
3	287	13	0	286	0	0

... ...

Link 6 (the sixth link) starts at node 3 and ends at node 287. From node 287, a left turn will lead to node 13, there is no straight movement, and a right turn will lead to node 286.

Simulation Scenarios and Analysis

The model considers an urban intermodal transportation network consisting of different travel models such as private car, rail, and HOV. It is designed to evaluate the overall system performance for a given intermodal network configuration and given time-dependent OD demand pattern. The model captures the interaction between mode choice and traffic assignment under different network control, pricing, and transit operation schemes as well as information supply strategies.

Simulation Scenarios and Testing Framework

In order to improve airport access for the DFW test network, it is necessary to determine test scenarios that would potentially improve the network performance. In an effort to meaningfully compare the test scenarios, it is important to understand how the system performs against a benchmark scenario. This is the base case performance; all other scenarios are compared to this base case to evaluate marginal improvements to the network. The overall framework details testing direct rail service from the off-airport terminals. The scenarios include varying the number of off-airport terminals, frequency of service, and cost. Figure 7.2 describes the methodology used for testing scenarios.

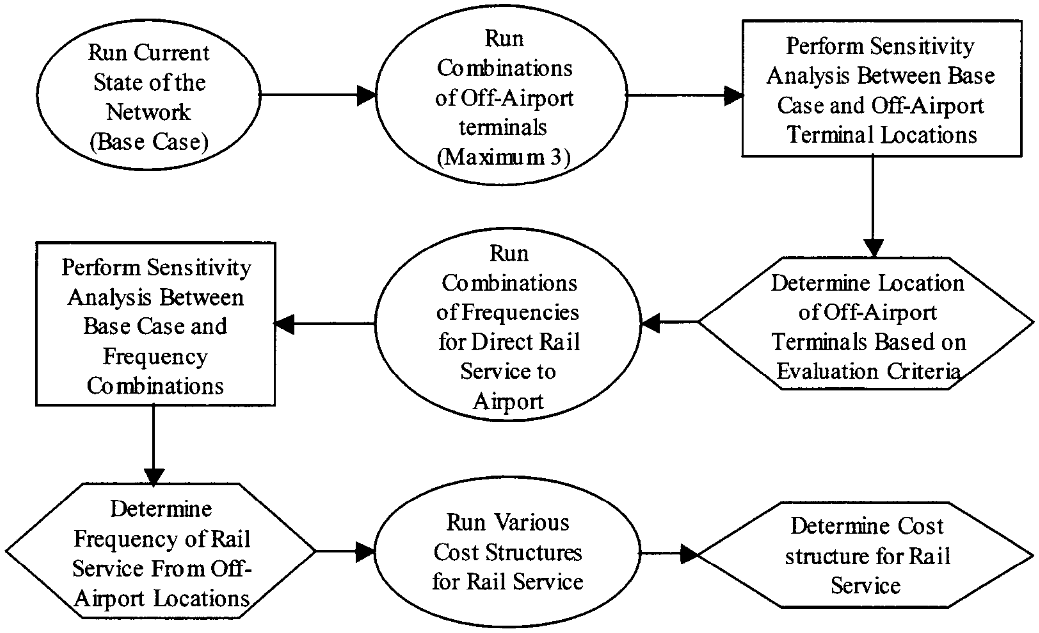


Figure 7.2 Framework for testing scenarios using DYNASMART-IP

Off-airport terminals are tested as a potential long-term solution strategy for alleviating congestion in the test network. Three potential locations are tested because of the high-demand patterns to the airport. These locations include downtown Dallas, downtown Fort Worth, and a northern suburb location.

Off-airport terminals are specified by the node and zone of its location. Direct rail service is modeled from the off-airport location to the airport. The high speed rail is modeled DYNASMART as an exclusive HOV lane with high speed bus. By assigning a high cost for autos traveling in the HOV lane, this alleviates most cars from choosing the HOV lane to reach the airport. Therefore, the only mode choosing the HOV lane is the high speed (rail). Different combinations of the off-airport test locations and rail are tested to point to a combination that improves the congestion surrounding the airport.

The second subset of test scenarios includes varying the frequency of rail service from the off-airport terminals to the airport. Typically, industry standards for public transportation for frequency are 15, 30, and 60 minutes. Therefore, the test scenarios for frequency are 15, 30, and 60 minutes to align with industry standards. The various frequency levels are evaluated and compared to the base case to identify an appropriate frequency level.

The final subset of test scenarios to be modeled addresses the cost structure. The cost to the airport traveler is a key component in the decision to use off-airport terminals. Therefore, it is important to test different realistic cost levels and evaluate the benefits to the individual traveler as well as the impact on the overall network. The three cost levels considered consist of \$1, \$2, and \$3.

Simulation Results

Travel time is not the only criterion that travelers consider while choosing their preferred travel modes and routes in intermodal networks. Other conflicting objectives such as trip cost, road tolls, parking costs, waiting time, transit availability, and the number of transfers along the route could be very important factors in determining the route-mode choice. However, for system evaluation purposes, three different measures are used to compare the different scenarios: 1) average traveler travel time, 2) average passenger time, and 3) average vehicular (rail and auto) travel time. The tables below summarize the effect of each scenario on network performance, which includes modal split and traffic assignment.

Demand of travelers is generated over 35 minutes of peak period. The simulation is terminated and statistics are collected when all travelers reach DFW Airport. Travelers are assumed to have pretrip information on available alternatives. They are assumed to evaluate these different alternatives according to a prespecified deterministic utility function in which the attributes associated with each alternative are evaluated in terms of a generalized cost measure. Two main attributes are considered in these experiments: 1) total travel time and 2) travel cost for the trip. The modal options available for each individual are as follows: 1) private car and 2) private car to satellite station and rail service to airport. In each scenario, the average travel time for all travelers, average travel time for passengers only, and vehicular travel time (for rail and autos) are presented. The trip share for each option is recorded as well.

Table 7.1 gives the effect of off-airport stations on modal split and traffic assignment. When trip cost is ignored, and travel time is considered as the only choice criterion, the model estimates less than 1% of the travelers using transit. Including trip cost as a relevant criterion in addition to the trip travel time increases the estimated transit share. This transit share increases with the variety of off-airport terminal locations. A significant improvement in the network performance is observed with the increase in off-airport terminal locations. For example, the average traveler travel time decreases by about 2% with the addition of the downtown Dallas off-airport terminal. Corresponding savings of about 1% are estimated in the average passenger travel time. These savings increase linearly with the addition of the downtown Fort Wort off-airport terminal. The model appears to adequately capture sensitivity of mode choice to location. The exploratory variable examined here suggests some likely degree of success of location mechanisms to induce modal shifts.

The effect of imposing transit fees at the off-airport terminals is presented in Table 7.2. Considering such fees in the travelers' mode-route choice process reduces the private car share and increases the transit share. For example, introducing $2.00 rail fees reduces the private car share by about 7%. The reduction in the private car share leads to a reduction in the average travel time by about 6.5%. When this fee is increased to $3.00, the private car share decreases by 10% and the average traveler time is improved by about 11%.

Table 7.3 shows the effect of increasing the rail frequency on rail trip share and overall network performance. According to the obtained results, increasing the rail frequency does not appear to significantly affect the rail trip share in these experiments. Increasing the rail frequency from once per hour to once every 30 minutes decreases the private car share by less than 1%. Increasing the rail frequency to once every 15 minutes decreases the private car share by less than 1% as well. Although an increase in rail service frequency would reduce the average passenger waiting time, the average overall travel time by rail is still higher than that by car. As such, improving transit service *alone* may not be sufficient to attract private car users on transit and reduce the private car usage. Other measures which could induce them to reduce using their cars have to be accompanied with such improvement in the transit service as illustrated by the results of these scenarios. The results appear to be consistent with previous findings and conclusions about the relatively low potential of alternatives to the private automobile for airport access.

Table 7.1 Effect of off-airport stations on modal split and traffic assignment

Satellite Station	**Downtown Dallas Station**	**Downtown Ft.Worth Station**	**North Station**
Average traveler Travel Time (min)	19.45	19.12	18.97
Average Passenger Travel Time(min)	21.01	20.98	20.12
Average Vehicle Travel Time(min)	19.04	19.84	19.41

Table 7.2 Effect of transit fee at satellite stations on modal split and traffic assignment

Rail Fare	**\$0.00**	**\$1.00**	**\$2.00**	**\$3.00**
Private Car Share	98.2%	95.3%	91.5%	90.0%
Downtown Dallas Station Share	1.0%	2.4%	4.5%	5.7%
Downtown Ft.Worth Station Share	0.6%	2.0%	2.7%	3.2%
North Station Share	0.2%	0.3%	1.3%	1.1%
Average traveler Travel Time(min)	21.26	20.25	19.86	19.00
Average Passenger Travel Time(min)	23.45	21.74	20.41	19.65
Average Vehicle Travel Time(min)	21.02	19.98	19.07	18.84

Table 7.3 Effect of rail frequency at satellite stations on modal split and traffic assignment

Rail Frequency (Number /Hour)	**1**	**2**	**4**
Private Car Share	98.6%	98.3%	98.0%
Downtown Dallas Station Share	0.2%	0.3%	0.4%
Downtown Ft.Worth Station Share	0.1%	0.2%	0.4%
North Station Share	0.1%	0.2%	0.2%
Average traveler Travel Time(min)	21.85	21.65	21.56
Average Passenger Travel Time(min)	22.95	24.68	25.78
Average Vehicle Travel Time(min)	21.45	22.36	22.69

Summary

The models presented in this chapter capture the dynamic interaction between mode choice and traffic assignment and also estimate the effect of this interaction on the overall network performance. Sections 2 and 3 described the input files of DYNASMART-IP. One set of experiments studied the effect of off-airport terminal locations. Other measures such as rail cost and frequency were also examined. These experiments illustrate the significance of including the mode choice dimension in the Dynamic Traffic Assignment (DTA) framework. The results are intended to illustrate the application of a dynamic simulation-assignment methodology to the analysis of intermodal transportation networks, such as the network surrounding the DFW Airport.

Chapter 8.
Conclusion

Summary

The need for planning and management of the airport access system and its interfaces with the airport system is well recognized and grows in urgency with continuing increase in air travel amid concern for passenger security. In order to address access problems, we need to understand both the behavior of air travelers and the effect of new services on congestion. This project examined the factors that influence passengers' preferred arrival time (PAT) at the airport prior to the scheduled flight departure and their willingness to use new airport access services such as transit or rail. This report also examined the use of a dynamic intermodal simulation-assignment methodology, DYNASMART-IP, for understanding the ways new intermodal policies would affect airport groundside access and evaluating their impact at the network level.

Travelers' behavior is affected by various individual attributes (demographic, psychological, and social) that interact with features of the surrounding environment to produce specific activity-travel behaviors. According to the analysis of the revealed and stated airport arrival time preferences, individuals who usually travel for business favor smaller buffers. Travelers who fly to an international destination prefer to have larger buffers. Older people are likely to arrive early at the airport. Traveling with another person usually reduces the buffer size. Being a licensed driver also reduces the buffer size. Ordered probit models captured air travelers' behavior in terms of their preferred arrival time and willingness to adopt new access services. The first set of models focused on the revealed and stated preference for the time to arrive at the airport for DFW and Austin travelers. The second set was concerned with the propensity to use different access modes for travelers from three of Texas's major airports.

Older travelers are more likely to use the new services, especially bus and rail, which is the case for DFW and Houston. Frequent flyers, on the other hand, are less likely to use such services. Similarly, business travelers using Dallas/Fort Worth International Airport (DFW Airport) indicate little interest in bus or rail. However, frequent flyers are more likely to use the services when traveling from Austin. Sociable and energy conscious travelers are interested in using the proposed services especially in Dallas/Fort Worth and Houston. On the other hand, Austin's sociable travelers are indifferent about the services, while Austin's energy conscious travelers have shown an interest in using the bus. Travelers who have a need for control and independence are less likely to use the new proposed airport access modes.

The results from the surveys indicate that travelers claim some willingness to use the new airport access modes. This is especially the case for transit and rail. It was observed that the percentage of travelers who indicated they would *definitely* use transit varies from about 20% in Austin to 74% in Houston. Moreover, it is predicted that 28% of Houston's travelers would be using rail. That figure drops to 19% in Dallas/Fort-Worth and to 8% in Austin. It was estimated that about 34% of DFW's travelers would probably use off-airport terminals. The percentage of travelers who would probably use off-airport terminals drops to about 28% in Houston and 19% in Austin. However, these numbers must be viewed with considerable caution, as they are based on what are called *stated* preferences, rather than actual behavior. Survey respondents, especially in the realm of mode choice and new services, are known to say one thing yet do another. *Willingness to use* a nonexistent service is very different from actually using the service when it becomes available. Experience in the U.S. has been mixed at best with regard to adoption of alternative modes for airport access and must, therefore, temper the interpretation of stated preference results.

The predicted probabilities of using the three proposed airport access options in the three cities of interest showed that travelers appear to have greater interest in using transit and rail as opposed to off-airport terminals. A reason for this could be because they can relate to the former two options, as both of them do exist in one form or the other in the U.S. On the other hand, no off-airport terminals are in operation in the U.S. today. Naturally, these are only very coarse projections and are typically fraught with error. As noted, stated preference responses are affected by the fact that options are hypothetical and that respondents sometimes tend to want to give the *right* answer (Ref 42). However, while the magnitude of the predicted demand may not be reliable, the relative importance of the factors that determine users' preferences and access-related travel behavior provide important insight for market segmentation and service design.

To develop a methodological approach for the understanding, evaluation, and alleviation of the airport access problem, DFW Airport was used as an illustrative example. Based on an understanding of the airport access problems faced at DFW Airport, the following alternative airport access recommendations were made:

- Addition of two off-airport terminals (downtown Dallas and Fort Worth locations)
- Direct rail service every 30 minutes from off-airport terminals to the airport
- Cost of rail service, \$2.00

These recommendations were tested using the DYNASMART-IP simulation-assignment methodology and shown to improve the overall network performance, as well as shared ride mode share. The recommendations are derived from not only the overall network performance but also cost and level of service issues. In simulating the test network, the results showed little change in ride share with increasing rail frequency. However, with the time sensitivity of air travelers, rail frequency every hour would attract few travelers who already depend on their cars. In order to attract more riders, it is necessary to increase the frequency to at least every 30 minutes and potentially every 15 minutes during peak times such as holidays. The cost of rail service was not a stand-alone variable, but to remain competitive with other transit options \$2.00 was selected as the one-way cost for service to the airport. The most apparent improvement to the network came in the locations of the off-airport terminals. The downtown Dallas and Fort Worth locations showed significant improvements to the network. However, it is not likely that the modest improvements suggested by the analysis would justify the cost of providing these alternatives.

Recommendations

The information obtained from the revealed and stated PAT models could be used in designing the new access services, because the frequency of operation and the pickup locations would have an influence on the arrival time at the airport.

The results from the stated preference models gave an indication of the type of passenger that is likely to use the service. It was observed that old, sociable, and energy conscious travelers are candidates for such services. As such, plans for designing new transit or rail access services should take into account the needs of such travelers. Moreover, in all three cities, females make up the highest percentage of travelers who indicated they would *definitely* use transit. Similarly, frequent flyers are more likely to use transit as opposed to nonfrequent flyers. Females and frequent flyers constitute a major portion of the traveler market. For example, in the 1998 San

Francisco Airport (SFO) Air Passenger Ground Access Survey, the percentages of females and frequent flyers were 46% and 43%, respectively.

The survey responses helped to identify means through which passengers preferred to obtain information. The most popular information medium was the Internet. Such a medium could be used to market the service through targeted campaigns not only to residents of the area but also to non residents. This is especially true because those flying into the airport seem particularly interested in obtaining information. This is reasonable as a large percentage of those flying into an airport are non residents who may not know about the transportation services available (Ref 5). Thus, targeting that traveler market will provide them with a full range of transportation options, which would help alleviate the congestion affecting the airport access system.

In that regard, using Advanced Traveler Information Systems (ATIS) to disseminate information about the new services would give travelers a means of knowing about the transit options available. For example, details of the new ground transportation modes could be integrated into the actual reservation system used by the airlines. On the one hand, airlines and ground transportation service providers can collaborate in providing such a service, which would be of benefit to both parties. On the other hand, non residents would be informed of the transportation services available at the destination airport.

The scenario recommendations examined for the DFW region involve the participation of several organizations, such as the Texas Department of Transportation (TxDOT) and Dallas Area Rapid Transit (DART). To successfully compete for federal funding, airport access plans and programs often require the approval of regional or federal agencies. Airport planners must have a basic understanding of the federally mandated transportation planning and programming process to successfully integrate their access plans with other transportation plans and programs and to compete for federal funding of airport access improvements. The respective roles of the agencies involved are described in Table 8.1. The table pinpoints the specific roles of the planning organization for airport access needs. The planning organizations often need guidance regarding analysis techniques, rules of thumb, and other data that is useful for planning airport access needs.

Table 8.1 State and local agencies' roles in airport ground access planning

Organization	Role
Texas Department of Transportation	-Distribute federal funds -Provide state aid to local airport authorities -Plan state airport systems -Design, construct, and maintain highways that provide ground access to airports
MPOs	-Develop regional transportation plans and coordinate efforts of municipalities
Municipalities and Local Jurisdictions	-Plan, design, construct, and maintain transportation facilities and services outside airport boundaries
DART	-Provide rail access to airport

Future Research

Several possible extensions of the present work are likely to benefit airport and regional planners. In this report, and because of the limited number of responses from the Houston survey, we were not able to estimate PAT models using that data set. One suggestion would be to re-administer the survey using larger mailing lists, which would increase the number of candidate respondents and maybe combine that with results from surveys administered at Houston's George Bush Intercontinental Airport. Such data could help in attaining a more complete picture of the variation in respondents' characteristics in relation to their PAT at the airport. Research should also focus on travelers from other states and abroad. Such studies would help understand the determinants of the travel behavior processes of air travelers and support the design of new services tailored for their needs.

Airport access is a complicated problem that spans over various organizations therefore it is important that each agency understands its role. As airport access and our air system changes, so does each agency's role. Therefore, it is necessary to evaluate the effectiveness of these and other recommendations on a regular basis. The steps taken in this project should mirror the steps taken as airport access is evaluated in the future. This process should become a part of the 5 -10 year master-planning process that each agency performs.

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Appendix A: Air Passenger Survey

Thank you for participating in our survey about passenger ground transportation choices. This research is being conducted by the Center for Transportation Research at The University of Texas at Austin. Please answer all questions to the best of your knowledge. All answers, of course, will be kept strictly confidential.

Section 1: Situational Characteristics (trip related)

1. Have you ever traveled from or to Dallas/Fort Worth International Airport (from or to refers to air trips that originate or end at the airport)?	Yes No (Go to END)
2. What was the final flight destination of your last trip from Dallas/Fort Worth Airport (DFW)?	City ____________ State (if in the US) __________ Country __________
3. Was this trip nonstop or did it involve any connections? If you had to make connecting flights, then how many?	Nonstop 1 2 3 4 or more
4. At approximately what time was your flight scheduled to take off?	
5. What was the primary reason for your trip?	Convention / conference-related Other work-related business travel Vacation Visit friends / relatives School travel Going back home Other (please specify)
6. Including yourself how many people were traveling in your party?	1 (traveled alone) 2 3 4 5 or more

7. How many pieces of luggage did you check with the airline on that flight?	0 1 2 3 4 or more
8. What was the total length of your trip (in days)?	__________ day (s)
9. Did anyone go into the terminal to see you off? If so, how many persons?	0 (No one) 1 2 3 4 or more
10. During the past 12 months, how many times have you flown out of DFW?	Never, this is my first time Once or twice Three to four times About once every month More than once a month
11. Which of the following best describes your status?	I live or work in the Dallas/Fort Worth area (Go to section 2) I am a visitor in the Dallas/Fort Worth area
12. How many times have you visited the Dallas/Fort Worth area?	This is the first time Once before Two to four times before More than four times
13. Did you research information about traveling to the airport?	Yes No (Go to 14)
14. What kind of information did you obtain? (check all that apply)	Map of the city Transit schedule Weather information Parking information Other (please specify):

15. Which resource(s) did you use to gather this information? (check all that apply)	Yellow pages Radio Internet Television Guide book Travel agency Electronic kiosk Telephone information line Friends/relatives Transit schedule book Other (please specify):
16. What types of information would be helpful to have before your trip to the airport? (check all that apply)	Map of the city Transit schedule Weather information Parking information Shortest route to the airport Delays on specific routes Terminal congestion Other (please specify):
17. What types of resource (s) are you most likely to use to gather such information?	Yellow pages Radio Internet Television Guide book Travel agency Electronic kiosk Telephone information line Friends/relatives Transit schedule book Other (please specify):

<u>Section 2:</u> Access Mode Choice (Attributes of the mode)

18. From what location did you travel to get to the airport?	A hotel / motel Your place of work A business you were visiting Your residence The home of a friend or relative A convention center / meeting facility Other (please specify):

19. What was the address at that location?	Street ____________ Zip Code ____________
20. At approximately what time did you leave for the airport?	_______________ AM / PM
21. At approximately what time did you arrive at the terminal?	_______________ AM / PM
22. How long before your scheduled flight departure time did you arrive at the terminal?	Less than 30 min 30 min to 1 hour 1 to 2 hours More than 2 hours
23. How long before your scheduled flight departure time would you prefer to arrive at the airport if traffic / parking were not an issue?	10 min 10 to 30 min 30 min to an hour 1 to 2 hours More than 2 hours
24. What form of transportation did you use to get to the airport?	Private vehicle (Go to 25) Rental car (Go to 31) Free hotel shuttle (Go to 40) Public transportation (Go to 34) Door-to-door van (Go to 38) Taxi (Go to 40) Other (please specify):
25. How many vehicles did you, and those accompanying you, use to travel to the airport?	1 2 3 or more
26. Including yourself, how many people were in the vehicle that you used to get to the airport?	1 (alone) 2 3 4 or more
27. When you arrived at the airport, did you go directly to a parking lot or were you dropped off at the terminal?	To a parking lot (Go to 28) Dropped at terminal
28. Was the car you arrived in parked at or near the airport until you return?	Yes No

29. How much did you pay for parking? $ __________

30. If you parked, even for a short period of time, where was it parked?

Terminal parking (Go to 40)
Infield parking (Go to 40)
Reduced rate parking (Go to 40)
Shuttle parking (Go to 40)
Hotel (please specify) (Go to 40)
On street near airport (Go to 40)
Other (please specify): (Go to 40)

31. What company did you rent the car from?

Advantage
Avis
Budget
Enterprise
Hertz
Payless car rental
National
Alamo
Dollar
E-Z Rent
Thrifty
Other (please specify):

32. Did you use the rental car for any trips other than driving to and from the airport?

Yes
No

33. Including yourself, how many people were in the same vehicle that you used to get to the airport?

1 (alone) (Go to 40)
2 (Go to 40)
3 (Go to 40)
4 or more (Go to 40)

34. Which transportation services did you use to get to the airport?

DART
Fort Worth Airporter
Charter bus
Shared-ride shuttle
Limousine
Other (please specify):

35. Where did you first board this transit service for this trip to the airport?

____
____
____

36. How did you get to that place?	Dropped off Walked Drove Other (please specify):
37. How many transfers did your trip involve?	0 1 2 or more
38. How far in advance did you schedule your use of transit services?	Didn't schedule A few hours before the flight departure 24 hours in advance 1 to 2 days before More than 2 days in advance
39. How much did the trip to the airport cost?	$ ___________

Section 3: Access Mode Choice (mode-related attitudes and perceptions)

40. How would you describe the general level of congestion on the streets and highways between your home and the airport?	Not congested at all Slightly congested Very congested Extremely congested Don't know
41. In general, how would you rate public transportation between your home and the airport?	Excellent Good Fair Poor Non existent Don't know

In the following section we would like your opinion about different travel modes to the airport. The first part asks you to rate drive-alone travel while the second part asks you to rate a ride-sharing travel mode of your choice.

42. Please estimate the average length of time it takes to drive from your home to the airport by car

Less than 10 min
10 to 30 min
30 min to 1 hour
1 to 2 hours
More than 2 hours

43. Please rate *drive-alone* travel to the airport for each of the following characteristics:

	Very good	Good	Fair	Poor	Very poor
Speed	( )	( )	( )	( )	( )
Promptness	( )	( )	( )	( )	( )
Safety	( )	( )	( )	( )	( )
Comfort	( )	( )	( )	( )	( )
Expense	( )	( )	( )	( )	( )
Flexibility	( )	( )	( )	( )	( )
Ease of use	( )	( )	( )	( )	( )
Proximity of parking	( )	( )	( )	( )	( )
Independence	( )	( )	( )	( )	( )
Privacy	( )	( )	( )	( )	( )

44. Which *shared-ride* choice have you used most frequently? If you have never shared a ride to the airport, which would you most likely use if you did not have access to a car?

Shared-ride van
Public transportation
Other (please specify):

45. Please estimate the average length of time it takes to travel from your home to the airport using your "shared-ride" choice.

Less than 10 min
10 to 30 min
30 min to 1 hour
1 to 2 hours
More than 2 hours

46. Please rate your choice for "shared-ride" travel to the airport for each of the following characteristics:

	Very good	Good	Fair	Poor	Very poor
Speed	( )	( )	( )	( )	( )
Promptness	( )	( )	( )	( )	( )
Safety	( )	( )	( )	( )	( )
Comfort	( )	( )	( )	( )	( )
Expense	( )	( )	( )	( )	( )
Flexibility	( )	( )	( )	( )	( )
Ease of use	( )	( )	( )	( )	( )
Proximity of parking	( )	( )	( )	( )	( )
Independence	( )	( )	( )	( )	( )
Privacy	( )	( )	( )	( )	( )

Section 4: Return Trip Mode Choice (attributes of the mode)

47. When was your last air trip that ended at Dallas/Fort Worth International Airport?	Never flown into DFW airport (Go to 62) Sometime this past week Past month Past 6 months More than a year ago
48. What was the purpose of that trip?	Convention / conference-related Other work-related business travel Vacation Visit friends / relatives School travel Coming back home Other
49. At approximately what time did your plane land at the airport?	________ AM / PM
50. Did your flight originate from the U.S. or outside of the U.S.?	In the US Outside of the US

51. Including yourself how many people were traveling in your party?	One (traveled alone) 2 3 4 5 or more
52. How many pieces of luggage did you check with the airline on that flight?	0 1 2 3 4 or more
53. Which of the following best describes where you stayed during your visit?	A hotel / motel Your residence The home of a friend/relative Other (please specify):
54. What was the address at that location (if it is the same address as above, please disregard this question)?	Street ____________ Zip Code ____________
55. What type of transportation did you use to get to that location from the airport?	Private vehicle Rental car Free hotel shuttle Public transportation Shared ride van Taxi Other (please specify):
56. Who paid for the trip from the airport to your destination?	I did Company or firm Institution I work for The trip was free Other (please specify):
57. Did you research information about traveling from the airport to your destination?	Yes (Go to 58) No (Go to 60)
58. What kind of information did you obtain? (check all that apply)	Map of the city Transit schedule Weather information Parking information Other (please specify):

59. Which resource(s) did you use to gather this information? (check all that apply)	Yellow pages Radio Internet Television Guide book Travel agency Electronic kiosk Telephone information line Friends/relatives Transit schedule book Other (please specify):
60. What type of information would be helpful to have before your trip from the airport? (check all that apply)	Map of the city Transit schedule Weather information Parking information Shortest route to your destination Delays on specific routes Terminal congestion Other (please specify):
61. What types of resource(s) are you most likely to use to gather such information?	Yellow pages Radio Internet Television Guide book Travel agency Electronic kiosk Telephone information line Friends/relatives Transit schedule book Other (please specify):

Section 5: Attitudinal Questions (Social/Environmental)

62. In this part, please give your reactions to the following statements by stating the extent to which you agree or disagree with each one.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
People should change their habits to save energy	( )	( )	( )	( )	( )
Pollution is destroying the environment	( )	( )	( )	( )	( )
Traffic congestion is something I have learned to deal with	( )	( )	( )	( )	( )
Auto emissions are a serious problem	( )	( )	( )	( )	( )
I feel the need to have a car at all times	( )	( )	( )	( )	( )
Traveling with others is enjoyable	( )	( )	( )	( )	( )
I prefer the privacy of being alone	( )	( )	( )	( )	( )
I do not like to depend on others	( )	( )	( )	( )	( )
I like meeting new people	( )	( )	( )	( )	( )
Driving a car gives me a feeling of control	( )	( )	( )	( )	( )
People like me drive to the airport	( )	( )	( )	( )	( )
I am willing to change my habits to save energy	( )	( )	( )	( )	( )

Section 6: Stated Response to New Services

In this section, we would like to get your reactions to some possible new ride-sharing or transit services. The services will be described, and then you will be asked questions about your willingness to use and your reactions to these services.

Suppose a new transit service has been initiated serving your home area to the airport with a travel time 15 minutes longer than your current travel time to the airport. At the transit terminals, you can park your car where the parking rate is a flat $2/day. This service features comfortable, air-conditioned buses that will have stops within a 15-minute drive from your home and will drop you off at the airport terminal. The buses will provide service every 20 minutes during the rush hour and they will be in operation from 5 a.m. until midnight. The fare for the one-way and round trip will be 50 cents.

63. How likely would you be to use this service?	Very unlikely Unlikely Probably Definitely
64. Suppose the buses costing 50 cents were to provide service every 10 minutes during the rush hour. How likely would you be to use this service?	Very unlikely Unlikely Probably Definitely
65. If the bus stops were within a 10-minute drive from your home, and the buses were to provide service every 20 minutes during the rush hour at a cost of 50 cents, how likely would you be to use this service?	Very unlikely Unlikely Probably Definitely
66. Suppose that the parking rates at the airport were all increased by a flat $3 rate. How likely are you to use the transit service at a cost of 50 cents with a 10-minute drive and service every 20 minutes?	Very unlikely Unlikely Probably Definitely

Now, consider the case where rail service is provided between the airport and downtown Dallas and Fort Worth. At the stations, you can park your car where the parking rate is a flat $2/day. Trains will depart from the terminals every 30 minutes during the rush hour and they will be in operation from 6 a.m. until midnight during weekdays and until 2:00 a.m. on weekends. The total trip will be 10 minutes shorter than your current travel time to the airport. The service will be dependable, and the rail coaches will be air-conditioned and comfortable. The one-way fare will be $3 and for a round trip it will be $5.

67. How likely would you be to use this service? | Very unlikely
Unlikely
Probably
Definitely

68. If the one-way fare was reduced to $2 and the round-trip fare to $3, how likely would you be to use this service? | Very unlikely
Unlikely
Probably
Definitely

69. Suppose the trains costing $3 for a one-way ride were to provide service every 15 minutes during the rush hour. How likely would you be to use this service? | Very unlikely
Unlikely
Probably
Definitely

70. Suppose that the parking rates at the airport were all increased by a flat $3 rate. How likely are you to use the rail service at a cost of $3 for the one-way trip and $5 for the round trip with service every 30 minutes? | Very unlikely
Unlikely
Probably
Definitely

Finally, imagine establishing terminals in downtown Dallas and Fort Worth. At these terminals, you can park your car where the parking rate is a flat $2/day. Vans, which will carry up to fifteen passengers, will depart from the terminals every 15 minutes during the rush hour and they will be in operation from 5 a.m. until midnight. The total trip will not be more than 15 minutes longer than your current travel time to the airport. The service will be dependable, and the vans will be air-conditioned and comfortable. You will be dropped off at the airport terminal and the one-way fare will be $15 and for a round trip it will be $25.

71. How likely would you be to use this service? | Very unlikely
Unlikely
Probably
Definitely

72. If the one-way fare was reduced to $12 and the round-trip fare to $20, how likely would you be to use this service? | Very unlikely
Unlikely
Probably
Definitely

73. Consider the case when there is no parking charges at the downtown terminals and the one-way fare to the airport is $15 and for the round trip it is $25, how likely would you be to use this service?	Very unlikely Unlikely Probably Definitely
74. Suppose that the same service is provided but rather than having to check in your luggage at the airport yourself, you can check it in at the terminal and get your boarding pass. Thus, once at the airport, you can proceed directly to your gate of departure. How likely would you be to use this service?	Very unlikely Unlikely Probably Definitely

<u>Section 7:</u> Situational Characteristics (sociodemographics)

75. In which city and state (or country, if not in the U.S.) do you live?	(City:) ___________________ (State or country:) ___________ Zip code ________
76. What is your age?	Under 18 18 - 21 22 - 29 30 - 39 40 - 49 50 - 59 60 or more
77. What is your gender?	Male Female
78. What is the highest level of education you have completed?	Not graduated high school Graduated high school Graduated technical school Some college Graduated college Post-graduate degree
79. Do you have a driver's license?	Yes No

80. How many people are there in your household including yourself?	1 2 3 4 5 or more
81. How many of them, including yourself, hold a driver's license?	0 1 2 3 4 or more
82. How many automobiles are available to your household?	0 1 2 3 4 or more
83. Do you consider yourself as having ready access to an auto in your household?	Yes No
84. Which best represents your household's income per year?	Less than $15,000 $15,000 - 24,999 $25,000 - 34,999 $35,000 - 39,999 $40,000 - 49,999 $50,000 - 74,999 $75,000 - 99,999 Over $100,000
85. How many times do you usually make air trips?	Less than once a year Once or twice a year 3 – 4 times a year Once a month More than once a month
86. Usually when you make air trips they are for?	Work-related business Visiting friends or relatives Leisure Other (please specify):

87. During the above-mentioned trips, usually you would be traveling	Alone With other members of your household With other co-workers With friends or relatives
88. If you do organize any meetings or conferences, are they held at/near the airport?	I don't organize any meetings/conferences Meetings/conferences are organized near the airport Meetings/conferences are somewhere else
89. Please feel free to share with us any comments that you might have about this survey or the topic	
90. Would you like to receive the results from this survey?	Yes (Go to 91) No (Go to END)
91. Please type your email address so that we can send you the results.	

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